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EUROPEAN ASSOCIATION FOR POTATO RESEARCH

EUROPÄISCHE GESELLSCHAFT FÜR KARTOFFELFORSCHUNG

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Aims – To promote the exchange between the various countries of scientific and general information relating to all phases of the potato industry and to encourage and assist international co-operation in the study of problems of common interest in this field. These aims are to be achieved through the setting up of subject sections for the study of specialized problems; the holding of an international conference in a different country every three years; by publishing the European Potato Journal.

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EUROPÄISCHE ZEITSCHRIFT FÜR KARTOFFELFORSCHUNG

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MECHANICAL DAMAGE TO POTATOES II[1]

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Summary, Résumé, Zusammenfassung, p. 224

INTRODUCTION

In the first part (*European Potato Journal*, Vol. 3 No. 1 (1960)) it was explained to what extent mechanically damaged potatoes are found in practice. When they are being prepared for delivery the percentage of damaged tubers in the various batches varies from 10% to 100%. Most of this high percentage of damage is caused during lifting, especially when potato harvesters are employed. Hence every precaution should be taken to reduce this harvesting damage to a minimum. This can be done on the one hand by improving the design of the harvesters (limiting the height of fall, providing a rubber lining, etc.) and on the other the farmer should take the necessary care in setting his machine. The presence of soil on the harvester provides the potatoes with a safeguard against damage so that it is advisable to take this into account during lifting.

As well as during lifting the potatoes may be damaged during transit, loading and unloading from the bins, grading, etc. In all these handling operations the necessary care should be observed. Later in the season the potatoes are less sensitive to external injury, but on the other hand they have a greater tendency to blue discolouration. Potatoes with a high starch content or which are deficient in potassium are particularly sensitive to this. Before removing such potatoes from the storage they should be warmed up to 13°–18 °C, since it has been found that the sensitivity to blue discolouration decreases with increasing handling temperature.

The previous article dealt with the occurence of mechanical damage and its prevention; the present article will consider the economic significance of mechanical damage.

[1] Part I has been published in *Eur. Potato J.*, Vol. 3 No. 1, p. 30-46 – *Partie I a été publiée dans Eur. Potato J., Vol 3. No. 1, p. 30-46 – Der I. Teil wurde im Eur. Potato J., Vol. 3 No. 1, S. 30-46 veröffentlicht.*

Damage is a factor determining:

1. the quality of potatoes
2. losses occurring during peeling
3. the occurrence of rotting
4. weight losses through evaporation
5. respiration losses of potatoes
6. the quality of potato starch

1. THE QUALITY OF POTATOES

In 1950 the annual consumption of potatoes in Holland was 125 kg per capita of the population; the present figure is about 90 kg. A decline in potato consumption may also be observed in most other Western European countries. For instance, a few years ago the potato consumption in Western Germany was 150 kg per capita of the population, where as the present estimate is rather more than 100 kg. This decline is primarily due to the present boom, but in addition the quality of the product is also an important factor. Generally speaking it can be stated that the important role played by Dutch potatoes on the international market is largely due to the care bestowed on the exported product. Owing to the rapid development of mechanization in potato growing (chiefly in harvesting), the capacity of the machines being the chief consideration, the quality of their work being considered less important, there has been a substantial increase in recent years in the percentage of injured tubers. Since it is the latter that largely determines the quality, the prevention or reduction of injury has become an important problem.

When we speak of the quality of potatoes we usually mean in the first instance the internal or cooking quality. This is an assemblage of characteristics (colour, flavour, dryness, structure, mealiness, disintegration, consistency) which together determine the cooking quality of the product. This internal quality of potatoes is determined by cooking samples of potatoes and afterwards tasting and evaluating them.

Mechanical injury affects the external quality of the tubers. It is true to say that both the internal and external characteristics of potatoes determine the quality of the product. The external quality is determined by the presence of observable defects (diseases and injuries). The grading, tuber shape, sprouting, colour (e.g. green), the firmness of the potatoes and the presence of soil also determine the external quality.

In the U.S. this external quality of potatoes is a predominant factor. An inquiry held in the U.S. into the complaints of potato consumers showed that the chief criticisms made related to grading and mechanical injury in particular. On the other hand, complaints about the eating quality, i.e. the flavour of the potatoes, only amounted to a few per cent (Fig. 1). (J. A. BOUCHARD and A. L. PERRY – *University of Maine Bulletin*. No. 486, 1950.)

In Holland a great deal of attention is paid to the cooking quality of potatoes, but the external appearance of the tubers is also being increasingly taken into account. It will be clear to everyone that injury is an important factor in this connection. Severely

FIG. 1. Complaints made by customers in the U.S.A. about washed potatoes in handy packages

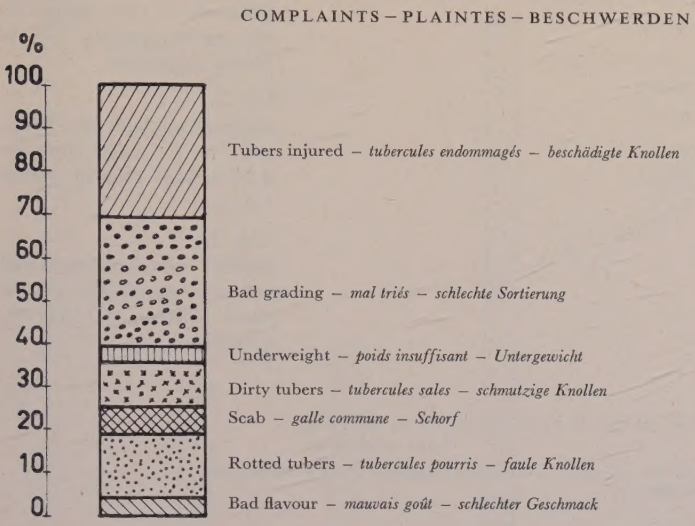


FIG. 1. *Objections de la clientèle en ce qui concerne les pommes de terre lavées vendues en petit emballage aux Etats-Unis*

ABB. 1. *Beschwerden von Käufern über gewaschene Kartoffeln in Kleinpackung in USA*

injured potatoes have to be removed. The most that can be done with these discarded potatoes is to use them as factory or fodder potatoes and this means a reduction in value. As the number of injured potatoes increases there will not only be an increase in the percentage of rejects but also grading will take more time, which means that grading costs are increased. After grading a large percentage of potatoes are always left behind which have moderate or slight external injuries, while the potatoes with internal injuries (blue discolouration) are impossible to grade. These potatoes greatly reduce the external quality of the product. By means of photographs it is possible to classify potatoes according to external quality. When there is a large number of injured tubers the potatoes in question are subdivided into a lower class, and this has to be reflected in the price of the product.

2. LOSSES OCCURRING DURING PEELING

Injured potatoes result in many losses during peeling. On this subject several experiments were performed with potatoes of the *Libertas* variety. Uninjured and injured potatoes were sorted on the grading machine. The injured potatoes were classified according to the type and degree of injury. Of each group 10 tubers were selected of about the same size. The potatoes were weighed individually on a precision balance. Each tuber was then thinly peeled with a hand peeler and the eyes removed (but not the injured portions). The resultant loss of weight is the normal peeling loss. This peeling loss greatly depends on the weight of the potato (FIG. 2).

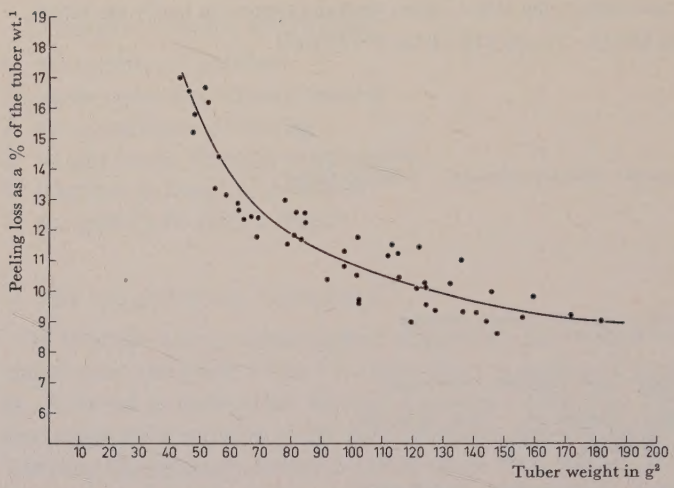


FIG. 2.
Influence of tuber weight on the normal peeling loss in *Libertas* potatoes

FIG. 2.
Influence du poids des tubercules sur les pertes normales à l'épluchage pour la variété Libertas

ABB. 2.
Einfluss vom Knollengewicht auf den normalen Verlust durch Schälen bei Libertaskartoffeln

[1] Pertes à l'épluchage en % du poids des tubercules – *Verlust durch Schälen in % des Knollengewichts.*
[2] *Poids des tubercules en g – Knollengewicht in g.*

In the case of a tuber weighing 40 g the normal peeling loss is about 17%. In a potato weighing 80 g the loss was less than 12%, whereas in a 160 g tuber the peeling loss was reduced to 9%. The hand peeler used in these experiments peeled the potatoes fairly thinly. When potatoes are peeled with a knife the peeling loss is usually higher, and mechanical peeling often results in even higher losses.

After the peeling loss had been determined the damaged areas were carefully removed and the tubers weighed again. The loss determined in this manner (resulting from the various forms of injury) is plotted in FIG. 3. Slight injuries increase this loss by about 2%. For moderate injuries the figure is 6,5%, while severe injuries result in an additional peeling loss of as much as 19%.

These experients were also carried out with other potato varieties, but the data above make it abundantly clear that the losses resulting from injuries caused during peeling are considerable and a great drawback to the consumer.

3. THE OCCURRENCE OF ROTTING

The potato skin forms a barrier against the penetration of micro-organisms. If the skin is damaged moulds and bacteria are easily able to infect the potato, as a result of which rotting will occur. In 1955 a preliminary test was conducted in order to ascertain the extent to which injury caused during harvesting promotes the occurrence of rotting (TABLE 1).

TABLE 1 shows that a difference in rotting occurred among samples from both potato harvesters; less rotting occurred with harvester A than with harvester B. This indicates that rotting hazards increase with increasing injury to the potatoes. In 1958 an experiment was conducted with *Voran* and *Record* potatoes. Samples of uninjured

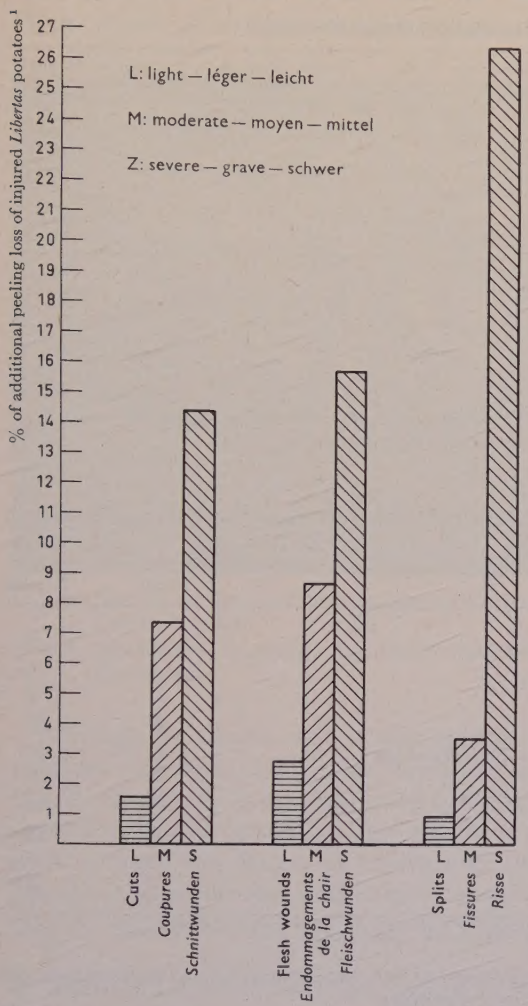


FIG. 3. The additional peeling loss caused by various types of injury

FIG. 3. *Pertes supplémentaires à l'épluchage causées par différents types d'endommagement*

ABB. 3. *Zusätzlicher Schälverlust bei Beschädigungen verschiedener Art*

[1] *Pertes supplémentaires à l'épluchage des pommes de terre endommagées en % (Libertas).*
Zusätzlicher Schälverlust beschädigter Libertaskartoffeln.

and injured potatoes were selected from each variety during harvesting. These samples of potatoes (100 tubers) were stored in nylon nets in a clamp between other potatoes. After being stored for two months the samples were evaluated for rotting (TABLE 2).

In the first place it can be concluded from TABLE 2 that potatoes rot more rapidly as a result of injury. After they had been kept in the pit for two months the rotting percentage was particularly high in the case of tubers with severe splits and severe flesh wounds. In the case of the *Record* variety the percentage of rotted tubers with severe flesh wounds even exceeded 60%.

It can also be seen that in this experiment more rotting usually occurred with the *Record* variety than with the *Voran* variety. This is probably due to the fact that the potatoes were only selected according to external injuries, internal bruises being ig-

TABLE 1. The importance of harvesting injury to the occurrence of rotting

Potato harvester *Arracheuse chargeuse* *Kartoffel-Vollerntemaschine*	Injured potatoes as a percentage of the total number of tubers *Tubercules endommagés en % du nombre total* *Prozentsatz von beschädigten Kartoffeln in der Gesamtknollenzahl*				Rotted tubers as a percentage of the total number on various dates *Tubercules pourris en % du nombre total à différentes dates* *Prozentsatz von faulen Knollen in der Gesamtknollenzahl an verschiedenen Daten*			
	light *légers* *leicht*	moderate *moyens* *mittel*	severe *graves* *schwer*	total % *pourcentage total* *Gesamtprozentsatz*	27. II	7. V	13. VII	total % *pourcentage total* *Gesamtprozentsatz*
A	25	3	1	29	0,1	0,0	1,7	1,8
B	29	6	4	39	0,6	0,7	6,9	8,2

TABLEAU 1. *Importance de l'endommagement à la récolte en ce qui concerne la pourriture*
TABELLE 1. *Bedeutung der Erntebeschädigungen auf das Vorkommen der Fäule*

TABLE 2. Percentage rotting of injured and uninjured *Voran* and *Record* potatoes after storage in a clamp for two months

Group – *groupe* – *Gruppe*	*Voran*	*Record*
Uninjured – *sans être endommagé* – *unbeschädigt*	7	0
Splits – *fissures* – *Risse* I	3	6
„ „ „ II	31	8
„ „ „ III	40	45
Flesh wounds – *endommagements de la chair* – *Fleischwunden* I	32	42
„ „ „ „ „ „ „ II	9	50
„ „ „ „ „ „ „ III	28	64
Cuts – *coupures* – *Schnittwunden* I	9	38
„ „ „ II	4	5
„ „ „ III	9	28

I: light – *légers* – *leicht*; II: moderate – *moyens* – *mittel*; III: severe – *graves* – *schwer*

TABLEAU 2. *Pourcentage de pourriture dans les pommes de terre endommagées et non endommagées des variétés Voran et Record après 2 mois d'ensilage*
TABELLE 2. *Prozentsatz der Fäule bei beschädigten und unbeschädigten Voran- und Recordkartoffeln nach zweimonatiger Einmietung*

nored. Since *Record* is a harder potato than *Voran* a *Record* potato requires an extremely heavy blow on the harvester to be severely damaged externally and there is also a change of internal bruising.

The nylon net on the left of the photograph (FIG. 4) was filled with potatoes having severe flesh wounds. After having been stored for two months a large proportion of these potatoes had started to rot and the sample resembled pulp as it was removed from the clamp. The net on the right contained uninjured potatoes from the same batch, stored under the same conditions. These were quite hard and sound.

FIG. 4. Injured (left) and uninjured (right) potatoes of the variety *Voran* after storage in a clamp for two months

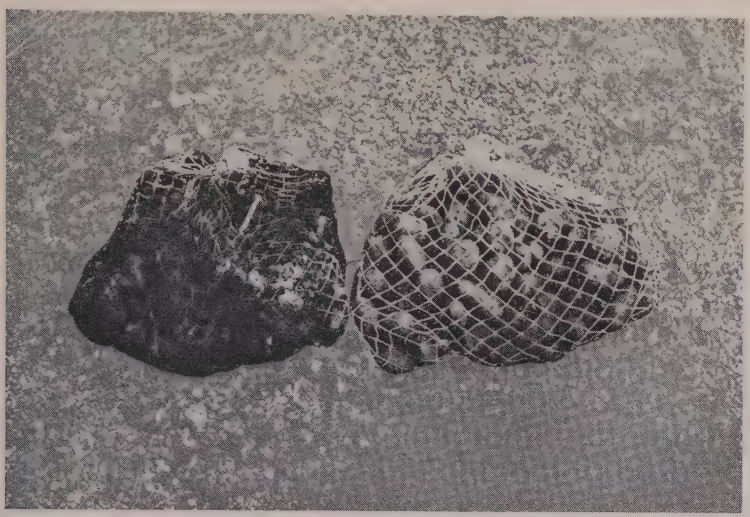


FIG. 4. *Pommes de terre endommagées (gauche) et non endommagées (droite) de la variété Voran après 2 mois d'ensilage*

ABB. 4. *Beschädigte (links) und unbeschädigte (rechts) Kartoffeln der Sorte Voran nach zweimonatiger Einmietung*

Although the figures show a wide spread, it follows from the above that injured potatoes soon begin to rot when stored in a clamp. On the other hand when they are stored with outside-air cooling, owing to the rapid drying and better cooling, the micro-organisms scarcely obtain an opportunity to attack the potatoes. Hence in this case there is much less danger of rotting even when the potatoes are severely injured. Storage experiments with outside-air cooling have nevertheless shown that even in this case the injured potatoes have a greater tendency to rot than uninjured tubers.

4. WEIGHT LOSSES THROUGH EVAPORATION

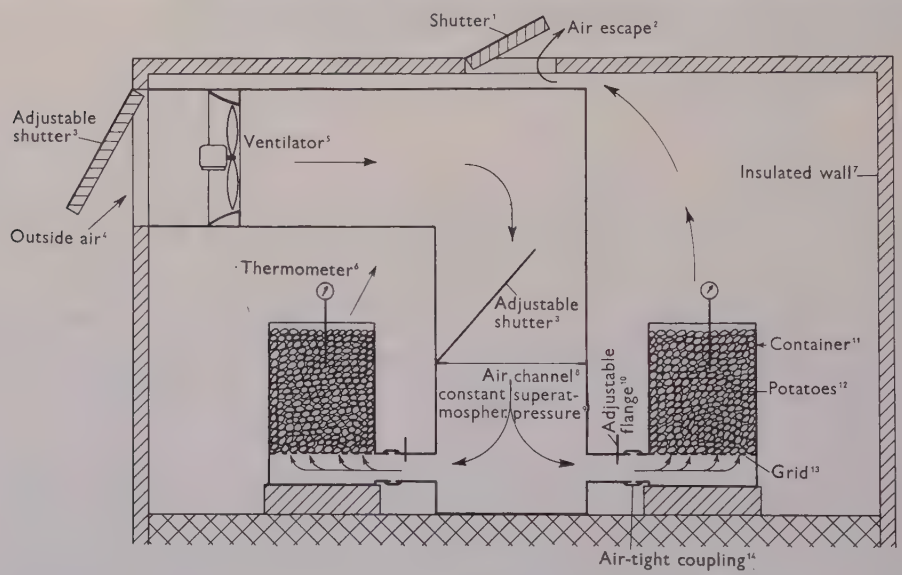
Over 75 % of a potato tuber consists of water. During storage there is loss of moisture owing to evaporation of water through the skin. The loss of a few per cent of moisture from the potatoes has no substantial effect on the quality of the product. When ware potatoes are stored without sprouts they remain hard and sound when the moisture loss is low. But if the moisture loss is high the potatoes become soft and the quality declines. Unripe potatoes lose much more moisture immediately after lifting than those from a crop lifted when ripe. Potatoes which have been topped and lifted some time afterwards show less loss of moisture than potatoes lifted while green. In the first instance the skin has a chance to suberise in the soil, thereby counteracting evaporation after lifting. This is because the degree of evaporation primarily depends of the thickness of the layer of cork.

It will be manifest that injured potatoes suffer greater evaporation losses than uninjured potatoes. This particularly applies to injuries in which a portion of the skin has been removed (external injuries). Owing to the injury moisture can readily escape from the tuber and the evaporating surface area of the tuber per unit of weight is also increased (for instance by flesh wounds and cuts).

Various experiments were carried out in order to ascertain to what extent the different types of mechanical injury affect the evaporation loss of potatoes. Potatoes were carefully lifted and afterwards the different types of injury were artificially inflicted. This prevented several different kinds of injury from occurring on the same potato. After infliction of the injuries the potatoes were stored in metal containers (empty petrol barrels provided with grids) connected to an air channel.

FIG. 5 shows diagrammatically the arrangement of these barrels. As in the case of an air-cooled storage shed, the potatoes in the barrels were also cooled by outside-air. Each group invariably consisted of 100 kg of potatoes and the loss in weight was ascertained at fixed times.

FIG. 5. Cross-section of the arrangement of containers for determining the loss in weight of potatoes



[1] *Volet – Klappe*
[2] *Echappement d'air – Luftaustritt*
[3] *Volet réglable – regulierbare Klappe*
[4] *Air extérieur – Aussenluft*
[5] *Ventilateur – Ventilator*
[6] *Thermomètre – Thermometer*
[7] *Paroi isolée – isolierte Wand*
[8] *Canal à air – Luftkanal*
[9] *Surpression constante – konstanter Überdruck*
[10] *Bride réglable – regulierbare Flansche*
[11] *Récipient – Behälter*
[12] *Pommes de terre – Kartoffeln*
[13] *Grille – Rost*
[14] *Raccord hermétique – luftdichte Kupplung*

FIG. 5. *Coupe transversale de la disposition des récipients pour la détermination des pertes de poids dans les pommes de terre*

ABB. 5. *Querschnitt der Anordnung von Behältern für die Bestimmung des Gewichtsverlustes von Kartoffeln*

A. *The loss in weight of seed potatoes*

On 19th July, 1957, a number of containers were filled with seed potatoes of the variety *Eigenheimer* which had been injured in various ways. The experiment consisted of the following groups:

1. Uninjured potatoes.
2. Skinned potatoes. The uninjured, recently harvested potatoes were placed in boxes. When the boxes were shaken the potatoes were rubbed against each other, becoming severely skinned in the process.
3. Flesh wounds. A fairly deep scratch was made in the potatoes with a large nail. The resultant injury corresponds fairly well to severe flesh wounds of the type caused by the harvester.
4. Cuts (share wounds). In order to obtain this type of injury the potatoes were cut into two parts with a knife. Both parts were then placed in the container.

From 19th July the various groups were weighed regularly. The weight losses are plotted in FIG. 6. This figure shows that the injured potatoes lose weight far more rapidly than the uninjured tubers.

After 120 days (4 months) of air-cooled storage the loss in weight of the uninjured potatoes was 7,5%, of the tubers with flesh wounds 11%, of the skinned potatoes 13,4% and of those with cuts as much as 15%.

When the potatoes are stored for a longer period there is an uniform increase in the weight losses of all groups. The great differences in moisture loss between groups chiefly occur during the first few days after lifting. After the potatoes have become sufficiently suberised a levelling takes place and it can be seen that with the exception of the share wounds, the injured potatoes evaporate to practically the same extent as the uninjured tubers. This means therefore that after suberisation has taken place evaporation is solely determined by the surface area. The infliction of share wounds in particular leads to a substantial increase in this evaporating surface area per unit of weight.

In 1958 this experiment was repeated with *Eigenheimer* seed-tubers. The results of this experiment are shown in FIG. 7. In this case also a distinct rise can be observed in the loss of weight of injured potatoes. After being stored for 120 days the loss of weight of the uninjured potatoes was 6,4%, of the potatoes with flesh wounds 9,4%, and of the skinned potatoes 10%. The potatoes with cuts had begun to rot after being stored for a fortnight.

The moisture loss was smaller in 1958 than in 1957, but in this experiment also there were distinct differences between the groups.

B. *The loss in weight of ware potatoes*

Experiments were conducted with ware potatoes in the same way as with seed potatoes. On 4th October 1957 *Libertas* ware potatoes were lifted and then injured and placed in containers. FIG. 8 shows that the loss in weight of ware potatoes as a result of evaporation is also greatly dependent on the injury. Generally speaking there is slightly less evaporation from ware potatoes than from seed potatoes.

FIG. 6. Weight losses in seed potatoes (*Eigenheimer*) injured in various ways in 1957 in air-cooled storage

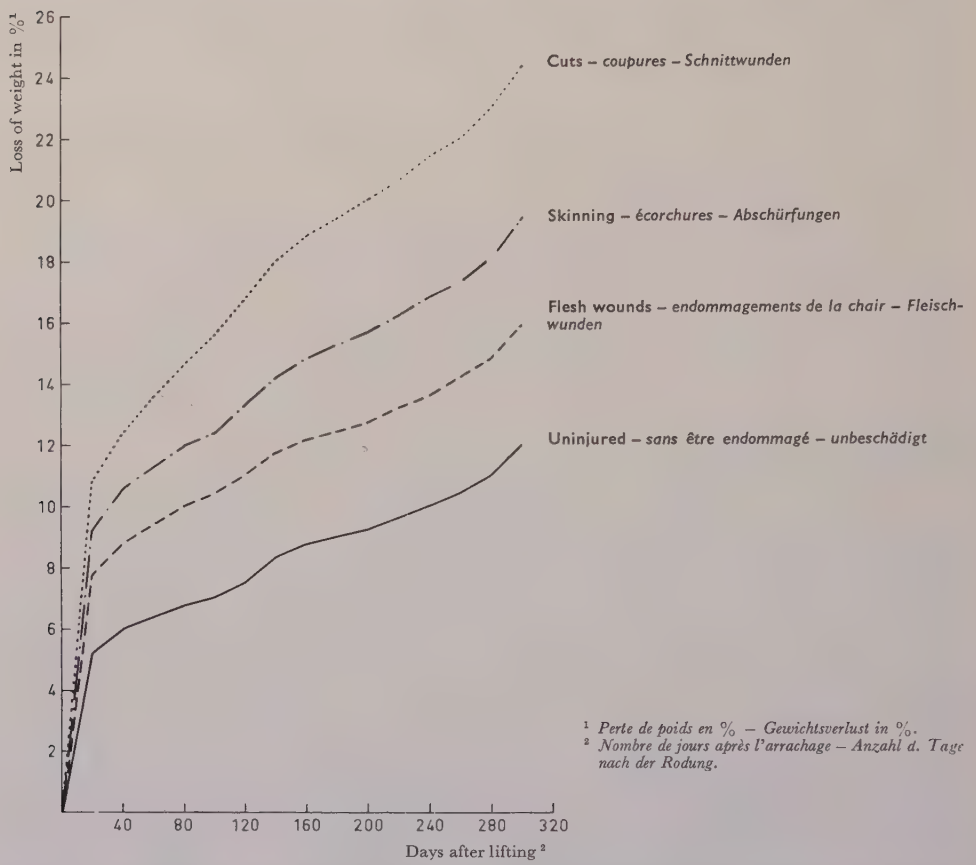


FIG. 6. *Pertes de poids dans des plants de pomme de terre (Eigenheimer) endommagés de différentes façons, durant la conservation sous refroidissement par l'air en 1957*

ABB. 6. *Gewichtsverluste von Saatkartoffeln (Eigenheimer) mit verschiedenen Beschädigungen bei luftgekühlter Lagering, 1957*

The 1958/1959 investigation also yielded similar results with ware potatoes.

It can therefore be concluded from these experiments that the losses in weight during storage are fairly high, particularly at the beginning. Losses in weight are increased by injuries.

5. RESPIRATION LOSSES OF POTATOES

In order to maintain the life processes in the potato tuber energy is required which is obtained by respiration of starch.

$$(C_6H_{10}O_5)\ n + 6n\ O_2 \rightarrow 6n\ CO_2 + 5n\ H_2O$$

FIG. 7. Weight losses in seed potatoes (*Eigenheimer*) injured in various ways in 1958 in air-cooled storage

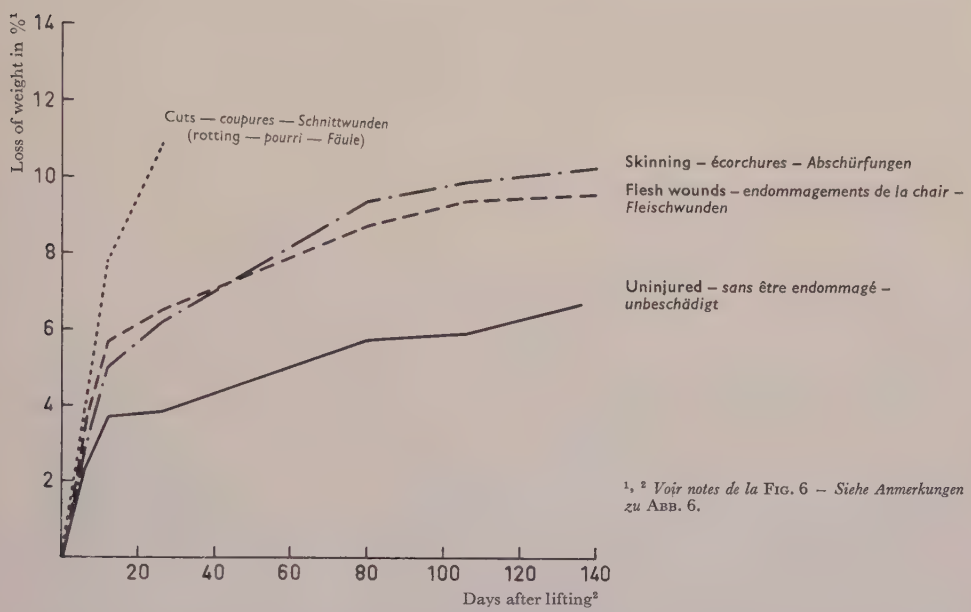


FIG. 7. *Pertes de poids dans des plants de pomme de terre (Eigenheimer) endommagés de différentes facons, durant la conservation sous refroidissement par l'air en 1958*

ABB. 7. *Gewichtsverluste von Saatkartoffeln (Eigenheimer) mit verschiedenen Beschädigungen bei luftgekühlter Lagerung, 1958*

The oxidation products formed (carbon dioxide and water) are secreted in the medium. The amount of CO_2 liberated is an index of the intensity of respiration. Losses in weight caused by respiration are much smaller than those due to evaporation. It is generally assumed that the losses in weight through respiration and evaporation are in the ratio of 1 : 10. This gives a very favourable picture of the respiration loss, but actually only moisture disappears from the tuber during evaporation, whereas during respiration the tuber losses a valuable component, *viz.* the starch.

It is generally assumed that after a potato tuber has been injured its life processes proceed more rapidly than in an uninjured tuber. When a potato has been injured it will try to recover from the wound by forming cork. For this suberisation energy is required which the tuber obtains by means of increased respiration. The cork layer formed is probably more porous than the original skin of the potato. Hence this will assist the exchange of gas during further storage as well and respiration can proceed at a more rapid rate. In order to discover how far this theory is correct a number of respiration measurements have been taken in recent years from injured and uninjured potatoes. For this investigation use was made of gas-tight containers provided with a

FIG. 8. Weight losses in ware potatoes (*Libertas*) injured in various ways in 1957 in air-cooled storage

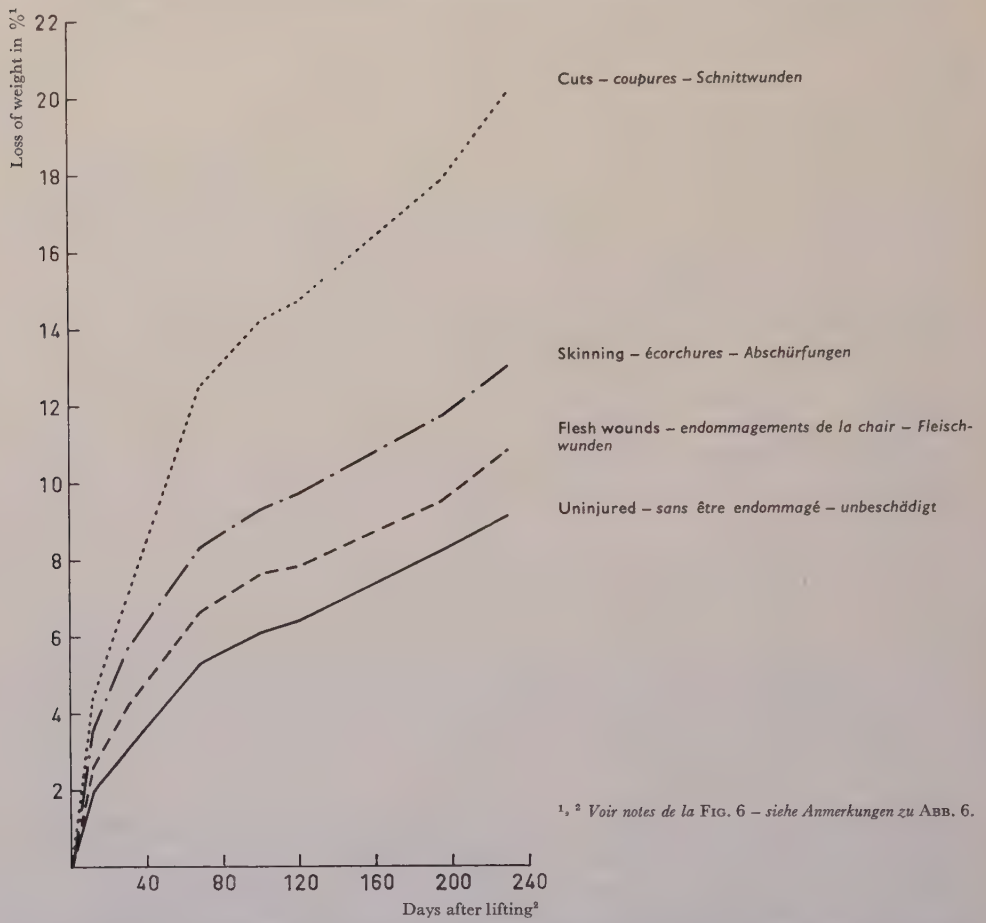


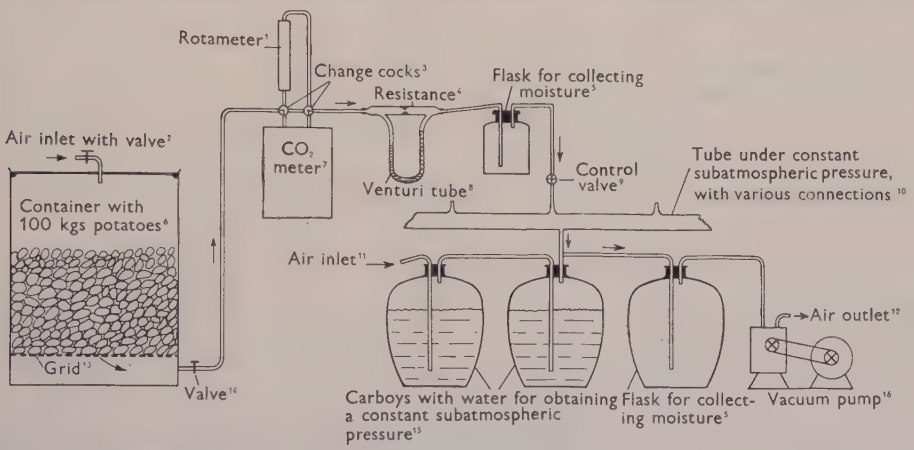
FIG. 8. *Pertes de poids dans des pommes de terre de consommation (Libertas) endommagées de différentes façons, durant la conservation sous refroidissement par l'air en 1957*

ABB. 8. *Gewichtsverluste bei Speisekartoffeln (Libertas) mit Beschädigungen verschiedener Art bei Lagerung mit Luftkühlung, 1957*

grid floor. These containers were filled with potatoes and exposed to constant temperatures. Air was aspirated from the container to the vacuum pump via a closed circuit and its amount measured with a rotameter. Afterwards the CO_2 concentration of about 2% was regularly maintained in the container; this concentration could be regulated by allowing a greater or lesser amount of air to flow through by means of a control shutter. This CO_2 content was required in order to obtain a reliable measurement of the CO_2 concentration which was determined daily with an Orzath apparatus. For this purpose an air sample of 100 cc from the containers was passed several times through a

KOH solution. The CO_2 dissolves in the caustic potash solution. Hence the reduction in volume of the air sample is the volume of CO_2 which was present in the air sample. In addition to the determination of the amount of air and the CO_2 concentration of the air the barometric pressure and the temperature of the measuring space was also taken daily. Venturi meters were also arranged in the air circuit in order to check the amounts of air (FIG. 9).

FIG. 9. Diagram showing the arrangement of equipment used for measuring the respiration of tubers



[1] *Rotamètre – Rotadurchflussmesser*
[2] *Entrée d'air avec valve – Lufteinlass mit Absperrventil*
[3] *Robinets à deux voies – Umschalthähne*
[4] *Résistance – Widerstand*
[5] *Flacon de recueillement de liquide – Flasche z. Auffangen von Feuchtigkeit*
[6] *Récipient avec 100 kg de tubercules – Behälter mit 100 kg Kartoffeln*
[7] *Dispositif de mesure de CO_2 – CO_2-Messvorrichtung*
[8] *Tube venturi – Venturirohr*
[9] *Valve de réglage – Regelventil*
[10] *Tube à souspression constante avec plusieurs raccords – Rohr mit konstantem Unterdruck mit verschiedenen Anschlüssen*
[11] *Admission d'air – Lufteinlass.*
[12] *Echappement d'air – Luftaustritt*
[13] *Grille – Rost*
[14] *Valve – Absperrventil*
[15] *Bombonnes remplies d'eau pour assurer une souspression constante – Korbflaschen mit Wasser zur Erzielung eines konstanten Unterdrucks*
[16] *Pompe à vide – Vakuumpumpe*

FIG. 9. *Schéma de l'installation pour les mesures de respiration de tubercules*
ABB. 9. *Schema der Anordnung für die Atmungsmessungen von Knollen*

All these measurements were necessary to enable the figures to be processed in such a way that the carbon dioxide production could be expressed in the form of starch losses.

The mathematical process was carried out as follows:

In the breathing experiments the volume of CO_2 that escapes per minute per 100 kg of potatoes was measured. This volume v, which is valid for a temperature of T in °K and a pressure of P mm Hg, follows from

$$v = \frac{K}{100} \times V$$

wherein V is the volume of air pumped through per minute and K the percentage of CO_2 in this air.

Treating CO_2 as ideal gas:
1 mol CO_2 (273 °K; 760 mm) = 22,4 litres
1 mol CO_2 (T°; P mm) = $22{,}4 \times \frac{760}{P} \times \frac{T}{273}$ litres.

Hence the number of mols of CO_2 per minute per 100 kg of potatoes is:

$$\frac{P \times v \times 273}{T \times 22{,}4 \times 760}.$$

From the equation

$$(C_6H_{10}O_5)n + 6n\ O_2 \rightarrow 6n\ CO_2 + 5n\ H_2O$$

it follows that 162 g starch → 6 mol CO_2.

Hence the amount of starch converted per minute per 100 kg of potatoes is:

$$^1/_6 \times \frac{P \times v \times 273}{T \times 22{,}4 \times 760} \times 162 \text{ g}$$

and per hour

$$60 \times {}^1/_6 \frac{P \times v \times 273}{T \times 22{,}4 \times 760} \times 162 \text{ g} = 10 \frac{P \times v \times 273}{T \times 22{,}4 \times 760} \times 162 \text{ g}.$$

In 1958 uninjured *Libertas* potatoes were lifted. Immediately after lifting the tubers were deliberately injured (skinning, flesh wounds, cuts) and placed in the containers. The containers were kept at various temperatures, after which the respiration was measured.

In FIG. 10 the starch loss is plotted for uninjured potatoes stored at different temperatures. We can see from this figure that respiration reaches a minimum at 5 °C. After 108 days the starch loss at a storage temperature of 5 °C is 4,6 kg per ton of potatoes. At 2 °C during the same period it is 6,7 per ton.

This higher starch loss at a low temperature is to be explained by the fact that the potatoes begin to form sugars at temperatures below 5° to 6 °C. Respiration is possibly activated by the high content of sugars in the potatoes.

FIG. 11 shows the respiration of potatoes stored at 5 °C which were injured in various ways. After being stored for 108 days the starch loss of undamaged tubers is 4,6 kg per ton of potatoes.

During the same storage period the figures were respectively 5,2 – 5,5 – 9,3 kg of starch per ton of potatoes for potatoes with skinning, flesh wounds and cuts. Hence this shows that cuts in particular give a considerably higher starch loss than uninjured tubers.

If we calculate these starch losses in percentages of the original weight of potatoes we can see that they are fairly slight, *viz.* from 0,5 % to 1 %.

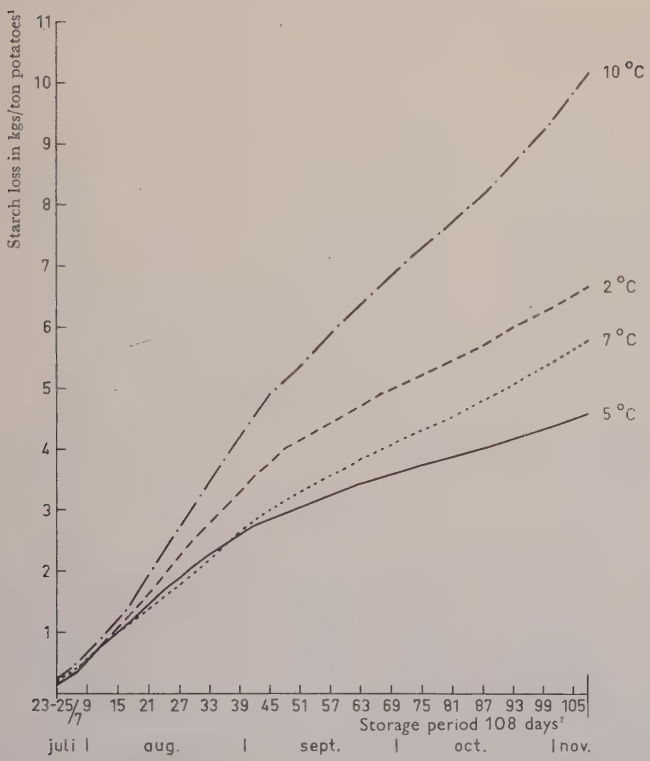


FIG. 10.
The effect of temperature on the starch loss of uninjured *Libertas* potatoes

FIG. 10.
Influence de la température sur les pertes de fécule dans les tubercules non endommagés (Libertas)

ABB. 10.
Einfluss der Temperatur auf den Stärkeverlust bei unbeschädigten Libertaskartoffeln

[1] *Perte en kg de fécule par tonne de pommes de terre – Stärkeverlust in kg pro Tonne Kartoffeln*
[2] *Durée du stockage de 108 jours – Lagerzeit 108 Tage*

6. THE QUALITY OF POTATO STARCH

The harvesters generally used for lifting factory potatoes have a large capacity, but a high percentage of the potatoes is damaged to a greater or lesser extent. When these damaged potatoes are stored in pits severe losses occur as a result of decay, evaporation and breathing.

It was first thought that damaged potatoes had no effect on the quality of the potato starch, but in recent years it has been clearly proved that injuries increase the dirt figure of the starch and that the colour also deteriorates. In 1958 an experiment was conducted on this subject under the auspices of the "Interprovincial Committee for the Improvement of the Quality of Factory Potatoes" in co-operation with the Institute for Storage and Processing of Agricultural Produce (I.B.V.L.), Wageningen, and the Groningen Experiment Station for Potato Processing. Various types of damaged potatoes were stored in a clamp used in practice, and at regular intervals samples were taken of which the starch quality was examined at the Groningen Experiment Station. It was found that damaged potatoes produced a substantially poorer quality of starch than undamaged ones. The quality of the starch decreased with increasing severity of the injuries of the tubers and duration of storage in the pit. The high dirt figure of injured potatoes is due to the fact that soil penetrates into the potato at the damaged

FIG. 11. The effect of various types of injured *Libertas* potatoes on the starch loss

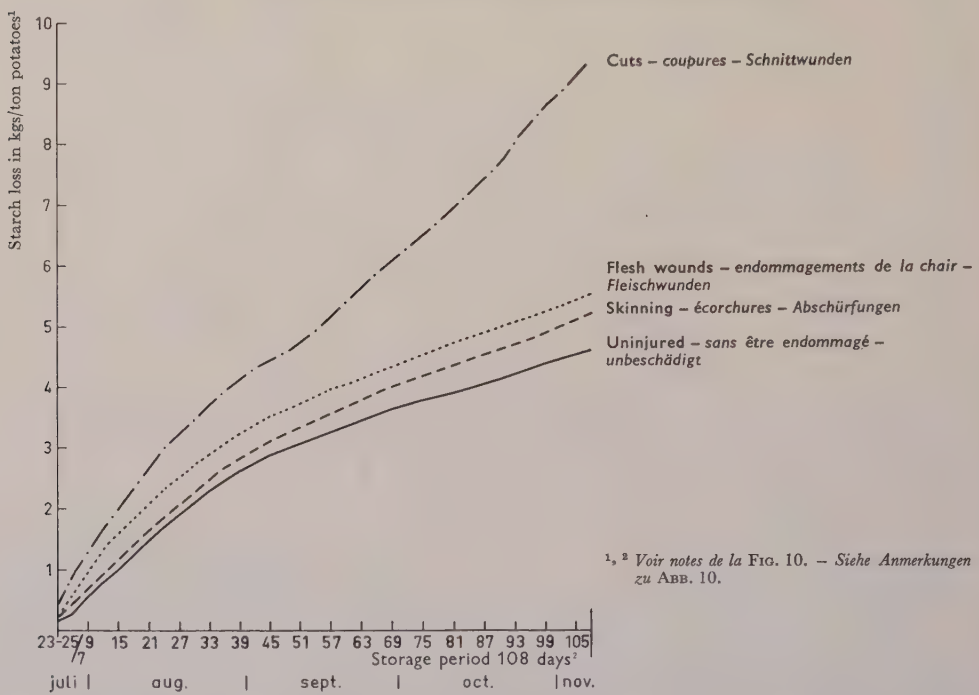


FIG. 11. *Influence des différents types d'endommagement des pommes de terre (Libertas) sur les pertes de fécule*

ABB. 11. *Einfluss verschiedener Beschädigungsarten auf den Stärkeverlust bei Libertaskartoffeln*

areas. Since the potatoes begin to form cork the soil particles are encapsulated. These soil particles cannot be removed in the potato starch factory, so that they ultimately find their way into the starch. Consequently several potato starch manufacturers have adopted the practice of paying for the potatoes according to external quality. The mechanically damaged potatoes play an important part in this connection.

SUMMARY AND CONCLUSIONS

From the field to the consumer potatoes are subjected to various types of handling (lifting, transport, storage, grading, etc.) as a result of which they may be damaged to a greater or lesser extent. In particular, constantly progressing mechanization in potato growing (harvesting) has meant a very great increase in recent years in the percentage of potatoes injured by mechanical means.

The problem of the mechanical injury of potatoes has been studied for some years at the Institute for Storage and Processing of Agricultural Produce (I.B.V.L.) Wageningen. Very little was known about the economic importance in particular of damaged potatoes, so that the necessary attention was paid to this aspect.

1. *The quality of potatoes*

Holland has a good name on the international market for the quality of its potatoes, but in-

creased mechanization has meant a substantial increase in injuries. It is important that this matter should receive more attention in the future. Severely damaged potatoes should be removed. The most that can be done with these rejects is to use them as factory or fodder potatoes and this generally means a great reduction in value. After grading a large percentage of potatoes are always left behind which have moderate or slight external damages, while the potatoes with internal damages (blue discolouration) are impossible to grade. It is obvious that these pptatoes reduce the external quality of the product.

In order to maintain the external quality of the potatoes at a reasonably high level every effort should be made to prevent mechanical damage of the product.

2. *Losses occurring during peeling*

Mechanical injuries not only have a bad effect on the external appearance of the potatoes, but there is also an increase in the losses during peeling. In the case of the *Libertas* variety mechanical injuries increased the peeling loss by 18%, 5,6% and 1,8% with slight, moderate and severe injuries respectively.

3. *The occurrence of rotting*

The potato skin forms a barrier against the penetration of micro-organisms. If the skin is damaged moulds and bacteria are easily able to infect the potato, as a result of which rotting may occur.

Experiments showed clearly that when stored in a clamp the damaged potatoes start rotting much sooner than the undamaged potatoes. On the other hand when they are stored with outside-air cooling, owing to the low temperature and intense air movement the micro-organisms scarcely obtain an opportunity to attack the potatoes. Hence in this case there is much less danger of rotting even when the potatoes are severely damaged. Storage experiments with outside-air cooling have nevertheless shown that even in this case the damaged potatoes have a greater tendency to rot than undamaged tubers.

4. *Weight losses through evaporation*

Over 75% of a potato tuber consists of water. During storage the potato loses moisture owing to evaporation of water through the skin. Without the presence of the skin the evaporation would be many times as great. It is therefore obvious that damaged potatoes have greater evaporation losses than undamaged potatoes. In the case of seed potatoes the weight losses of undamaged tubers, tubers with flesh wounds, tubers with skinning and tubers with cuts were respectively 7, 10, 12 and 15% after four months of air-cooled storage. Ware potatoes usually evaporate less than seed potatoes, although in this case also evaporation greatly depends on the mechanical damages.

The great differences in moisture loss between the groups chiefly occur during the first few days after lifting. After the potatoes have become sufficiently suberised there is a marked reduction in evaporation.

5. *Respiration losses of potatoes*

In order to maintain the life processes in the tuber energy is required which is obtained by the respiration of starch to carbon dioxide and water. It is generally assumed that the losses in weight through respiration and evaporation are in the ratio of 1 : 10. Injured potatoes respirate more intensively than uninjured ones so that there is a greater starch loss. After being stored for over three months at 5 °C the starch loss of uninjured *Libertas* ware potatoes was 4,6 kg per ton of potatoes. During the same storage period and at the same temperature the figures were respectively 5,2–5,5–9,3 kg of starch per ton for potatoes with skinning, flesh wounds and cuts. Respiration reached a minimum at 5 °C.

6. *The quality of potato starch*

Generally speaking factory potatoes are much more severely damaged during lifting than ware or seed potatoes. Consequently there are heavy losses through rotting when these potatoes are stored in pits.

In recent years it has been found that these injuries also lead to a deterioration in the quality of the potato starch. Several potato starch manufacturers have adopted the practice of paying for the potatoes according to the external quality. The mechanically damaged potatoes receive particular attention in this connection.

RÉSUMÉ

L'ENDOMMAGEMENT MÉCANIQUE DES POMMES DE TERRE II

Dans leur passage du champ au consommateur, les tubercules de pommes de terre subissent des traitements divers (arrachage, transport, stockage, triage, etc.) qui peuvent produire des endommagements plus ou moins importants. La proportion d'endommagement mécanique des tubercules a surtout augmenté ces dernières années par la mécanisation toujours croissante de la culture (arrachage).

Depuis quelques années, l'Institut de Recherches sur la Conservation et la Transformation de Produits Agricoles étudie le problème de l'endommagement mécanique des pommes de terre. Surtout l'importance économique de cet endommagement était encore très mal connue. Aussi a-t-on accordé l'attention nécessaire à cet aspect de la question.

1. *La qualité des pommes de terre*

Les Pays-Bas ont acquis en ce qui concerne la qualité de leurs pommes de terre une renommée sur le marché international. Mais le développement du machinisme agricole a fait augmenter la proportion d'endommagements. Il importe d'accorder une plus grande attention à cette question à l'avenir. Les tubercules gravement endommagés devront être écartés des lots.

Ces déchets pourraient servir tout au plus de pommes de terre industrielles au fourragères, ce qui signifie généralement une perte de valeur. Après le triage, il reste toujours dans le lot une forte proportion de tubercules légèrement et modérément endommagés, tandis que les tubercules intérieurement endommagés (bleus) ne peuvent être enlevés. Il va sans dire que la présence de telles pommes de terre diminue la qualité du produit. Pour maintenir la qualité extérieure des pommes de terre à un niveau convenable, il faudra s'efforcer d'éviter l'endommagement mécanique du produit.

2. *Pertes se produisant à l'épluchage*

L'endommagement mécanique détériore non seulement l'aspect des pommes de terre, mais fait également augmenter les pertes à l'épluchage. Pour la variété *Libertas*, les endommagements mécaniques ont fait augmenter les pertes à l'épluchage de respectivement 1,8%, 6,5% et environ 19% en cas d'endommagement léger, moyen et grave.

3. *La pourriture*

La peau de la pomme de terre constitue une barrière à l'invasion par les microorganismes. Quand la peau est endommagée, les moisissures et microbes peuvent aisément infecter la pomme de terre, ce qui peut causer une pourriture.

Il a nettement été démontré dans des essais qu'à l'ensilage, les tubercules endommagés sont beaucoup plus vite atteints de pourriture que les tubercules intacts. En cas de stockage sous refroidissement par l'air extérieur, par contre, la température basse et le fort mouvement de l'air ne permettent guère aux germes d'attaquer les pommes de terre. Aussi le risque de pourriture est-il bien plus faible ici, même pour les lots de tubercules gravement endommagés. Pourtant, des essais de conservation sous refroidissement par l'air extérieur ont permis de constater qu'ici encore, les pommes de terre endommagées pourrissent plus facilement que les tubercules intacts.

4. *Pertes de poids par évaporation*

Le tubercule de la pomme de terre contient $\pm 75\%$ d'eau. Durant la période de stockage, le tubercule perd de l'eau par évaporation à travers la peau. Sans la présence de la peau du tubercule, l'évaporation se trouverait multipliée. Il est donc évident que les pertes par évaporation sont plus fortes dans les pommes de terre endommagées que dans les tubercules intacts. Dans des plants de pomme de terre conservés pendant 4 mois sous refroidissement par l'air, la perte de poids dans les tubercules intacts, les tubercules présentant des endommagements de la chair, les tubercules écorchés et les tubercules tranchés étaient respectivement de 7, 10, 12 et 15%. Dans les pommes de terre de consommation, l'évaporation est en général légèrement inférieure à celle des plants de pomme de terre, mais ici encore, l'évaporation est fortement influencée par les endommagements mécaniques.

Les fortes différences de perte d'eau d'une catégorie à l'autre se manifestent surtout pendant les premiers jours après l'arrachage. Lorsque les pommes de terre ont atteint un degré suffisant de subérification l'évaporation se trouve fortement réduite.

5. *Pertes des pommes de terres par respiration*

Pour entretenir les processus vitaux dans les

tubercules de la pomme de terre, il faut de l'énergie, laquelle est obtenue par transformation métabolique de la fécule en acide carbonique et en eau. On admet généralement que les pertes de poids par respiration et par évaporation présentent un rapport de 1 à 10. Dans les tubercules endommagés, la respiration est plus intensive que dans les tubercules intacts, de sorte que la perte de fécule est plus importante. Après plus de 3 mois de stockage à 5 °C, la perte de fécule dans des pommes de terre de consommation de la variété *Libertas* non endommagées atteignait 4,6 kg par tonne de pommes de terre. Stockées durant la même période à la même température, les pommes de terre écorchées, à endommagements de la chair et les pommes de terre tranchées avaient perdu respectivement 5,2, 5,5 et 9,3 kg de fécule par tonne de tubercules. La respiration était minimale à la température de 5 °C.

6. *La qualité de la fécule*

En général, les pommes de terre industrielles sont bien plus gravement endommagées à l'arrachage que les pommes de terre de consommation ou de semence. Il en résulte qu'il se produit de grandes pertes par pourriture durant la conservation, qui se fait par ensilage.
Ces dernières années, il a été constaté que ces endommagements causent aussi une détérioration de la qualité de la fécule. Plusieurs fabriques de fécule ont commencé à payer les pommes de terre d'après leur qualité extérieure. Sous ce rapport, une attention particulière est accordée aux endommagements mécaniques des pommes de terre.

ZUSAMMENFASSUNG

MECHANISCHE BESCHÄDIGUNGEN BEI KARTOFFELN II

Vom Felde bis zum Verbraucher erfahren Kartoffeln verschiedene Behandlungen (Roden, Transport, Lagerung, Sortieren usw.), wodurch sie mehr oder weniger beschädigt werden können. Namentlich infolge der immer weiter durchgeführten Mechanisierung der Kartoffelkultur (Roden) ist der Prozentsatz der mechanisch beschädigten Kartoffeln erheblich gestiegen.
Seit einigen Jahren sind über die Frage der mechanischen Beschädigung bei Kartoffeln im I.B.V.L. in Wageningen Untersuchungen im Gange. Namentlich über die wirtschaftliche Bedeutung dieser Beschädigungen war noch sehr wenig bekannt und diesem Aspekt ist daher besondere Aufmerksamkeit geschenkt worden.

1. *Die Qualität von Kartoffeln*

Holland hat, was die Qualität seiner Kartoffeln anbelangt, auf dem internationalen Markt einen guten Namen. Im Zuge der zunehmenden Mechanisierung sind jedoch die Beschädigungen weit häufiger geworden. Es ist daher angezeigt, dieser Frage für die Zukunft mehr Aufmerksamkeit zu schenken. Schwer beschädigte Kartoffeln werden aus den Partien entfernt werden müssen.
Dieser Ausschuss könnte höchstens als Industrie- oder Futterkartoffeln verwendet werden, was normalerweise eine Wertverminderung bedeutet. Nach dem Sortieren bleibt immer noch ein hoher Prozentsatz Kartoffeln mit mittleren bis leichten Beschädigungen in der Partie zurück, während die Knollen mit inneren Beschädigungen (Bläue) sich nicht aussortieren lassen. Es ist klar, dass diese Kartoffeln die Qualität des Produktes herabsetzen. Um die äussere Qualität der Kartoffeln in angemessener Höhe zu halten, wird alles aufgeboten werden müssen, damit mechanische Beschädigungen des Produktes verhütet werden.

2. *Verluste beim Schälen*

Durch mechanische Beschädigungen wird nicht nur das Aussehen der Kartoffeln verschlechtert, sondern mehren sich auch die Verluste beim Schälen. Bei der Sorte *Libertas* erhöhte sich als Folge der mechanischen Beschädigungen der Schälverlust um 1,8% bzw. 6,5% und etwa 19% bei leichten, bzw. mittleren und schweren Beschädigungen.

3. *Auftreten von Fäule*

Die Kartoffelschale bildet eine Schutzwand gegen das Eindringen von Mikroorganismen. Wird die Schale beschädigt, so können Schimmel und Bakterien die Kartoffel leicht infizieren und so Fäule hervorrufen.
Versuche haben deutlich erwiesen, dass bei Einmietung die beschädigten Kartoffeln viel schneller faulen als unbeschädigte Knollen. Bei Aufbewahrung mit Aussenluftkühlung wird den

Mikroorganismen infolge der niedrigen Temperatur und der intensiven Luftbewegung kaum die Möglichkeit gegeben, die Kartoffeln anzugreifen. Die Gefahr, dass Fäule auftritt, ist daher in diesem Falle, selbst bei schwer beschädigten Partien, viel geringer. Immerhin konnte bei Aufbewahrungsversuchen mit Aussenluftkühlung nachgewiesen werden, dass auch hier die beschädigten Kartoffeln eher zum Faulen neigen als die unbeschädigten.

4. *Gewichtsverluste durch Verdunstung*

Eine Kartoffelknolle besteht zu ca. 75% aus Wasser. Bei Lagerung verliert die Kartoffel Feuchtigkeit durch die Verdunstung von Wasser durch die Schale. Ohne das Vorhandensein der Kartoffelschale würde die Verdunstung ein Vielfaches betragen. Es liegt also auf der Hand, dass der Verdunstungsverlust beschädigter Kartoffeln höher ist als bei unbeschädigten Kartoffeln. Bei Saatkartoffeln betrug nach einer Lagerung mit Luftkühlung während 4 Monaten der Gewichtsverlust bei unbeschädigten Kartoffeln, Kartoffeln mit Fleischwunden, Kartoffeln mit Abschürfungen und durchschnittenen Kartoffeln 7 bzw. 10, 12 und 15%. Bei Speisekartoffeln ist die Verdunstung im allgemeinen etwas geringer als bei Saatkartoffeln, aber auch hier ist die Verdungstung stark von den mechanischen Beschädigungen abhängig.

Die grossen Unterschiede im Feuchtigkeitsverlust kommen besonders in den ersten Tagen nach dem Roden vor. Nachdem die Kartoffeln genügend verkorkt sind, geht die Verdunstung stark zurück.

5. *Atmungsverluste von Kartoffeln*

Zur Instandhaltung der Lebensvorgänge in der Kartoffelknolle ist Energie erforderlich, die durch die Dissimilation von Stärke zu Kohlensäure und Wasser erzeugt wird. Allgemein wird das Verhältnis der Gewichtsverluste durch Atmung und Verdunstung mit 1:10 angenommen. Die Atmung bei beschädigten Kartoffeln ist intensiver als bei unbeschädigten, daher ist der Stärkeverlust grösser. Nach dreimonatiger Lagerung bei 5 °C betrug der Stärkeverlust bei unschädigten *Libertas*-Speisekartoffeln 4,6 kg je Tonne Kartoffeln. Während derselben Aufbewahrungszeit und bei derselben Temperatur betrug diese Ziffer bei abgeschürften Kartoffeln, Kartoffeln mit Fleischwunden und durchgeschnittenen Kartoffeln 5,2 bzw. 5,5 und 9,3 kg Stärke je Tonne Kartoffeln. Die Atmung war minimal bei einer Temperatur von 5 °C.

6. *Die Qualität von Kartoffelmehl*

Industriekartoffeln werden gewöhnlich beim Roden viel schwerer beschädigt als Speise- oder Saatkartoffeln. Infolgedessen treten bei Lagerung in Mieten grosse Verluste durch Fäule ein. In den letzten Jahren hat sich gezeigt, dass durch die Beschädigungen auch die Qualität des Kartoffelmehls beeinträchtigt wird. Mehrere Kartoffelmehlfabrikanten haben sich entschlossen, den Preis der Kartoffeln von der äusseren Qualität abhängig zu machen. Hierbei wird besonders auf die mechanisch beschädigten Kartoffeln geachtet.

SPECIFIC SYMPTOMS IN THE TUBERS OF MOSAIC-DISEASED PLANTS

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Summary, Zusammenfassung, Résumé, p. 235

INTRODUCTION

The obligatory date for early lifting in seed potato production depends upon a compromise between the state of health of the crop and the yield per hectare. Sometimes field examination fails to give a true indication of the percentage of virus diseases in the progeny.

More accurate information about the health of the stock can be gained by planting sample lots of seed potatoes in the field (Florida-test) or in glasshouses (Augenstecklingsprüfung) after harvesting. Methods which show specific aberrations in the tuber are easier to handle; this is, for example, the case with leaf-roll virus (Igel-Lange test).

Under certain conditions, e.g. with varieties that are susceptible only to leaf-roll virus, the latter method permits the character of the date of early lifting to be changed from an obligatory to an advisory one, and may even obviate the necessity for early lifting. This lowers the costs of production, but even more important is the argument that seed potatoes from a ripe crop may have a higher yield capacity than those from an early one, as is indicated by the experiments of BROADBENT (BROADBENT *et al.*, 1957).

It would, therefore, be interesting if specific symptoms could also be found in the tubers of plants infected with other viruses, especially those which cause mosaic symptoms. Tubers of mosaic-diseased plants were tested with this end in view.

Certain characteristics, which were absent in healthy tubers were present in tubers of these diseased plants. These symptoms were detected in the autumn of 1955, and further experiments were carried out in the following years.

METHOD AND MATERIAL

Sections about 1 mm thick were made across the length of the tuber.

Although the symptoms may be found everywhere, it appeared that most of them were present in the regions around the eyes.

After two or three sections have been cut away, the symptoms show up and remain in further sections. They appear most clearly around the margins of the sections.

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The tubers of secondary mosaic-diseased plants show symptoms while still growing; sometimes, however, symptoms can only be found a few days after lifting. Experiments conducted by Dr. J. OORTWIJN BOTJES (OORTWIJN BOTJES, 1956) proved that light had no promoting effect. Under normal storehouse conditions for seed potatoes, the symptoms remain until planting-time.

Sections were examined by holding them before a microscope-lamp with milk-glass or diffuse daylight.

DESCRIPTION OF THE SYMPTOMS

The characteristic difference between the tubers of healthy plants and those infected with mosaic-producing viruses is the occurrence of light spots in the flesh of the diseased tubers and the absence of these in healthy tubers (FIGS. 1, 2, 3 and 4).

The form and size of these spots differ; when seen macroscopically the sharp contours of the spots are striking but when seen microscopically these are vague.

Cells in the light spots definitely contain less starch.[1] The centre of the spot is very often somewhat darker.

EXPERIMENTS WITH SECONDARY-DISEASED TUBERS

Tubers of secondary mosaic-diseased plants of the varieties *Eigenheimer* and *Furore* were cut from 1955 till 1959. In 1957 the tubers of 106 plants were cut; in 95 plants all the tubers had symptoms, in 4 plants only some of the tubers had symptoms, and in 7 plants the tubers had no symptoms at all. For 119 plants tested in 1958, these numbers were respectively 109, 1 and 9.

Tuber-graftings were made in order to see which virus caused mosaic symptoms in the plants, since (especially with *Eigenheimer*) several viruses which cannot be easily differentiated give mosaic symptoms in the leaf.

Use was made of the old Dutch variety *Gelderse Rode* as indicator for virus A (reacting with a severe top necrosis) and *Eersteling* as indicator for virus Y (reacting with a severe crinkle) and stipple-streak virus, identical with the C strain of virus Y (reacting with necrotic stipples and streaks).

A total of 123 successful graftings were made in 1957, 1958 and 1959, and the following results were obtained (All the tubers had symptoms and were planted as well):

Variety	Total number of tubers	Number of plants infected with			
		Virus A	Stipple-streak virus	Virus A + stipple-streak virus	Virus Y
Eigenheimer	99	11	79	9	–
Furore	24	1	22	–	1

[1] According to information provided by Dr. J. OORTWIJN BOTJES (1956), tubers of stipple-streak-diseased plants contained more glucose and fructose (the experiment was carried out according to the chromatografic method by Dr. B. D. E. GAILLARD, Laboratory of Animal Physiology, Wageningen).

FIG. 1. *Eigenheimer*
left: Section of a tuber from a secondary mosaic-diseased plant. – right: Section of a tuber from a healthy plant.

ABB. 1. *Eigenheimer*
links: Längsschnitt der Knolle einer sekundär mosaikkranken Pflanze. – rechts: Längsschnitt der Knolle einer gesunden Pflanze.

FIG. 1. *Eigenheimer*
gauche: coupe d'un tubercule d'une plante atteinte de mosaïque secondaire. – droite: coupe d'un tubercule d'une plante saine.

FIG. 2. *Furore*
left: Section of a tuber from a secondary mosaic-diseased plant. – right: Section of a tuber from a healthy plant.

ABB. 2. *Furore*
links: Längsschnitt der Knolle einer sekundär mosaikkranken Pflanze. – rechts: Längsschnitt der Knolle einer gesunden Pflanze.

FIG. 2. *Furore*
gauche: coupe d'un tubercule d'une plante atteinte de mosaïque secondaire. – droite: coupe d'un tubercule d'une plante saine.

In quite a number of plants the *Eersteling* gave only very few necrotic spots, so that it is doubtful whether this variety is a satisfactory indicator for stipple-streak virus when tuber-grafting is used. This also possibly explains the fact that 11 *Eigenheimer*

FIG. 3. *Bintje*
left: Two sections of tubers from a secondary virus Y-diseased plant. – right: Section of a tuber from a healthy plant.

ABB. 3. *Bintje*
links: Zwei Längsschnitte der Knollen einer sekundär Y-Viruskranken Pflanze. – rechts: Längsschnitt der Knolle einer gesunden Pflanze.

FIG. 3. *Bintje*
gauche: deux coupes d'un tubercule d'une plante atteinte d'infection secondaire à virus Y. droite: coupe d'un tubercule d'une plante saine.

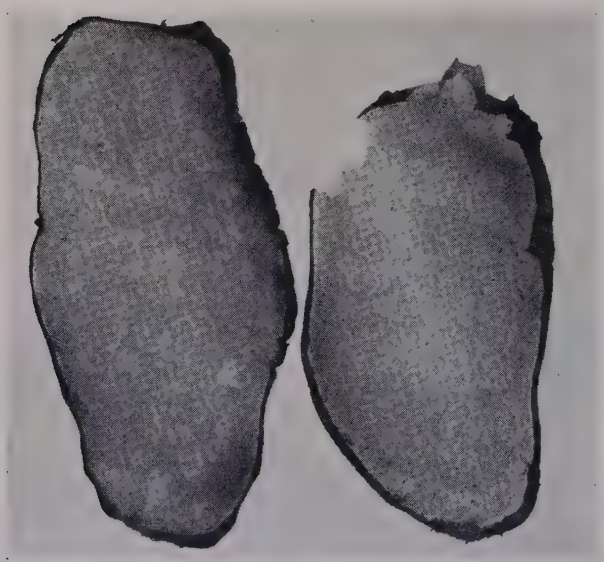

FIG. 4. *Bintje*
left: Section of a tuber from a plant with primary virus Y-infection. – right: Section of a tuber from a healthy plant.

ABB. 4. *Bintje*
links: Längsschnitt der Knolle einer Pflanze mit primärer Y-Virusinfektion. – rechts: Längsschnitt der Knolle einer gesunden Pflanze.

FIG. 4. *Bintje*
gauche: coupe d'un tubercule d'une plante atteinte d'infection primaire à virus Y. droite: coupe d'un tubercule d'une plante saine.

plants gave only a virus A reaction and could not be included under the joint heading „virus A plus stipple-streak virus".

It can, at any rate, be stated that stipple-streak virus – and not virus A as is commonly thought – is very frequent in *Eigenheimer*. The same applies to *Furore*.

The variety *Bintje* also showed that virus Y may cause the symptoms in the tuber. Secondary-diseased tubers, infected with the common virus Y, gave the same symptoms; in many cases, however, not all the tubers of a plant showed them and in some plants none of the tubers had symptoms.

According to other observations, it is possible that the potato veinal necrosis strain of virus Y also gives the same symptoms as those caused by the common virus Y.

EXPERIMENTS WITH PRIMARY-DISEASED TUBERS

In 1957 samples of 53 lots of seed potatoes of the variety *Eigenheimer* and of 55 lots of the variety *Furore* were tested for symptoms. Each sample numbered 100 tubers. In 1958 these samples were planted, the tubers which showed symptoms being planted separately.

Tubers with symptoms always gave mosaic-diseased plants. In the field, however, many more diseased plants occurred than tuber-testing would have revealed. In only a few samples did tuber-testing cover 50% or more of the total number of diseased plants.

Similar results were found in 1959 with 4 samples of *Urgenta*, 16 of *Eigenheimer* and 18 of *Furore*, which had been tested in 1958.

Symptoms were also found in tubers of the variety *Bintje*, from plants with primary virus Y infection.

A remarkable fact was the regular absence of the symptoms in the first-formed tuber and their presence in the second tuber, connected to the first one by a stolon. This was observed in 1957 with primary mosaic-diseased plants showing the so-called second growth (FIG. 5). Both tubers gave rise to secondary mosaic-diseased plants. This indicates that the occurrence of the symptoms depends largely on the physiological condition of the tuber. It might be possible that suitable treatment of seed potatoes could enhance the symptoms.

CONCLUSIONS

Specific symptoms can be found in the tubers of mosaic-diseased plants. They are caused by the stipple-streak virus, the common virus Y and probably also by the potato veinal necrosis strain of virus Y.

Very little is known yet about the conditions which give rise to these symptoms. Further research will be necessary, especially in order to show primary infection in the tuber.

Stipple-streak virus is, in most cases, the cause of mosaic in *Eigenheimer* and *Furore*.

FIG. 5. *Eigenheimer*, second growth 1957. Tubers from primary mosaic-diseased plants.
lower row: The first-formed tubers which showed no symptoms, but which gave rise to mosaic diseased plants in 1958. – upper row: The second-formed tubers which had symptoms and also produced mosaic-diseased plants in 1958.

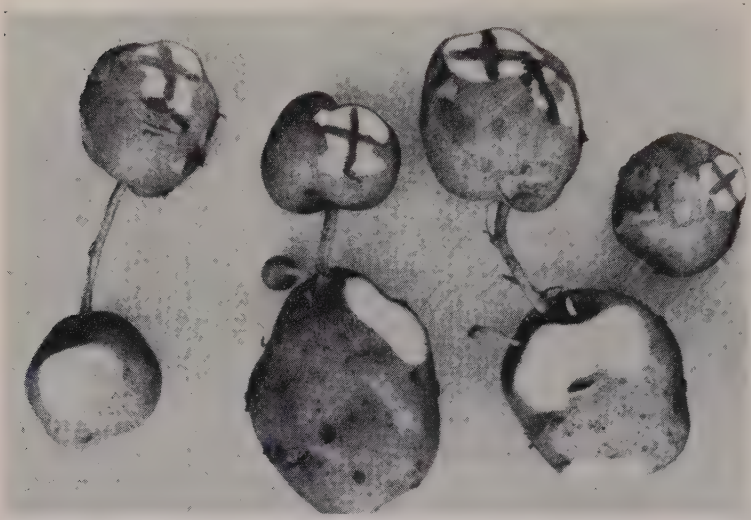

ABB. 5. *Eigenheimer, Durchwachs 1957. Knollen von primär mosaikkranken Pflanzen.*
unten: Erstgeformte Knollen, die keine Symptomen zeigten, jedoch in 1958 mosaikkranke Pflanzen ergaben. – oben: Später geformte Knollen, die Symptome zeigten und in 1958 auch mosaikkranke Pflanzen ergaben.

FIG. 5. *Eigenheimer, croissance secondaire en 1957. Tubercules de plantes atteintes de mosaïque primaire. – en bas: les tubercules primaires, qui ne présentaient aucun symptôme mais ont donné naissance à des plantes atteintes de mosaïque en 1958. – en haut: les tubercules secondaires, présentant des symptômes et ayant également produit des plantes atteintes de mosaïque en 1958.*

N.B. – *Anmerkung – Nota*
Photographs of FIGS. 1, 2, 3 and 4 were taken at the Institute for Phytopathological Research (I.P.O.), Wageningen, by Mr G. Eimers, and that of FIG. 5 was taken by Mr L. Batenburg, Barendrecht.
Die ABBILDUNGEN 1, 2, 3 *und* 4 *sind photographischen Aufnahmen des Herrn G. Eimers vom Institut für Pflanzenkrankheiten (I.P.O.), Wageningen, die* ABB. 5 *von Herrn L. Batenburg, Barendrecht.*
Les photographies des FIG. 1, 2, 3 *et* 4 *ont été prises à l'Institut de Recherches Phytopathologiques (I.P.O.) à Wageningen par M. G. Eimers, et celle de la* FIG. 5 *par M. L. Batenburg à Barendrecht.*

ACKNOWLEDGEMENTS

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SUMMARY

When tubers of the varieties *Eigenheimer*, *Furore*, *Bintje* and some other varieties were tested, characteristic symptoms were found in the tubers of mosaic-diseased plants, which were absent in healthy tubers. They are caused by stipple-streak virus and virus Y.

Little is known about the physiological conditions which influence the appearance of the symptoms. Further research will be necessary, especially to show primary infection in the tuber.

ZUSAMMENFASSUNG

TYPISCHE SYMPTOMEN IN KNOLLEN MOSAIKKRANKER PFLANZEN

In Knollen mosaikkranker Pflanzen der Sorten *Eigenheimer*, *Furore* und *Bintje* und von einigen anderen Sorten sind typische Symptomen gefunden, die in gesunden Knollen fehlen. Sie werden verursacht durch das Virus Y und das Virus C, welches ein Stamm des Virus Y ist.

Über die physiologischen Bedingungen für das Hervorrufen der Symptome ist nur wenig bekannt. Zur Determinierung der Primärinfektion in den Knollen sind weitere Untersuchungen notwendig.

RÉSUMÉ

SYMPTOMES SPÉCIFIQUES DANS LES TUBERCULES DES PLANTES ATTEINTES DE MOSAIQUE GRAVE

En cas d'atteinte de mosaïque grave, les tubercules des variétés de pommes de terre *Eigenheimer*, *Furore*, *Bintje* et quelques autres présentent des symptômes caractéristiques, qui font défaut dans les tubercules sains. Cette altération des tubercules est due au virus Y et au virus C, une souche du virus Y.

Les conditions physiologiques des tubercules qui peuvent influencer l'apparition de ces symptômes sont encore peu connues. Il sera nécessaire de poursuivre les recherches à ce sujet, en s'efforçant surtout de découvrir une infection primaire dans les tubercules.

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OBSERVATIONS ON THE DEVELOPMENT OF POTATO ROOT EELWORM, *HETERODERA ROSTOCHIENSIS* WOLL., ON THE POTATO TUBER AND THE IMPORTANCE OF SUCH DEVELOPMENT IN THE SPREAD OF THIS NEMATODE ON WASHED TUBERS

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Summary, Zusammenfassung, Résumé, p. 243

INTRODUCTION

For seed production potato crops should be grown on land free from Potato Root Eelworm, but there are some difficulties in the selection of such land. Heavy populations of the pest can be detected without difficulty by means of soil testing, but with light populations, the chances of detection are reduced. Some consignments of seed tubers may, therefore, originate in fields so lightly infested that the infestation is hard to demonstrate. As this pest has been recorded from every seed producing country in western Europe, this problem is common to all. Some degree of confidence in a negative result may be possible where a whole district has been sampled regularly and intensively without ever finding an infestation, but even in these areas low infestations may be building up. Although the danger of spread from lightly infested fields may be slight, the development of a process which would remove all cysts and soil present in a consignment of tubers would be a valuable contribution to the production of clean seed.

HISTORICAL

Until recently, seed-borne spread was generally believed to result only from the cysts carried in the soil adhering to the tubers. Cyst development on tubers had been recorded occasionally but this was regarded as a matter of academic interest rather than one of economic significance. The introduction of processes designed to free potato consignments from soil and, therefore, from cysts present in that soil, renewed interest in the role of the so called „embedded" cysts. It was suggested that these might be present within washed tubers and so cause eelworm spread.

Apparently the first reference in the literature to the development of cysts on tissues

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other than root tissues is an account by EDWARDS (1929) who noted that in all the cases of failure he examined in Lincolnshire the „roots and rhizomes" always bore large numbers of cysts. The development of cysts on stolons and tubers has been recorded in Holland (OOSTENBRINK, 1950) and cysts have been observed attached to tubers of the variety *Epicure* in Ayrshire (GRAINGER, 1951). More recently the development of cysts on the tubers of several commercial varieties and also on the tubers of a number of seedlings being bred for resistance to Potato Root Eelworm has again been reported from Scotland (DUNNETT, 1957). As, however, few records of the occurrence of cysts on tubers could be found in the literature and as a number of advisory officers in Scotland and England who were consulted stated that they had seen such cysts on a few occasions only, it appeared that such development was infrequent.

A preliminary trial at a commercial washing plant demonstrated that it was possible to remove the adhering soil from potato tubers (MABBOTT, 1956). These tubers, which had been grown in infested soil, were free from cysts when examined after washing. Accordingly, with the reservation that in rare cases „embedded" cysts might prove a danger, the principle of washing was accepted provisionally as a means of freeing from infestation tubers from lightly infested land.

An investigation into the biology, frequency and distribution of „embedded" cysts and the possibility of their removal by washing was undertaken and a preliminary report is given below.

INVESTIGATION

1. *Frequency and Distribution*

In late June and early July 1957 a number of infested potato crops in the Lothians and Ayrshire were examined. In seven crops the eelworm population was sufficiently heavy for cysts to be found without difficulty on the potato roots and in each of these crops white or yellow cysts were observed attached to tubers. In September a further eight infested crops were surveyed in the Lothians and cysts attached to tubers were noted in each case.

In 1958 the survey was continued with the examination during August of ten infested crops in the counties of Angus and Perth; these two counties being the main seed producing areas of Scotland. Cysts attached to tubers were found in each crop.

At East Craigs further observations were made in the course of pot experiments. The cysts used for these experiments had been collected from a number of localities and were bulked together. In all pots examined cysts were present on the tubers.

From these results it was concluded that the development of Potato Root Eelworm in the tubers and stolons is not specific to certain strains of the eelworm and that tuber infestation is co-existent with root infestation.

2. *Varieties attacked*

During the survey, cysts were found on the tubers of the variety *Epicure* in the Lothians and Ayrshire, the varieties *Craigs Royal*, *Great Scot*, *Home Guard*, *King*

Edward and *Redskin* in the Lothians and *Kerr's Pink*, *King Edward*, *Majestic*, *Redskin*, *Ulster Chieftain* and *Ulster Premier* in Angus.

DUNNETT (1957) reported that the varieties *Craigs Defiance*, *Craigs Royal* and *Pentland Ace*, and a number of resistant seedlings grown in an infested plot at Pentlandfield had cysts on the tubers. In 1957 and 1958 variety trials were carried out in this plot, three plants of each variety being grown. Most varieties were found to have cysts on the tubers and these are listed in the table below.

TABLE. Varieties on which cysts were observed attached to tubers

Arran Banner	(E.M.)	Dunbar Standard	(L.M.)	Pentland Ace	(S.E.)
Arran Chief	(L.M.)	Eclipse	(F.E.)	Record	(L.M.)
Arran Crest	(F.E.)	Edzell Blue	(S.E.)	Redskin	(E.M.)
Arran Peak	(L.M.)	Epicure	(F.E.)	Royal Kidney	(S.E.)
Arran Pilot	(F.E.)	Gladstone	(E.M.)	Sharpes Express	(F.E.)
Ballydoon	(F.E.)	Great Scot	(E.M.)	Ulster Chieftain	(F.E.)
Catriona	(S.E.)	Harbinger	(F.E.)	Ulster Dale	(S.E.)
Craigs Defiance	(E.M.)	Home Guard	(F.E.)	Ulster Gozo	(E.M.)
Craigs Royal	(S.E.)	Kerrs Pink	(L.M.)	Ulster Premier	(F.E.)
Di Vernon	(F.E.)	King Edward	(E.M.)	Ulster Supreme	(L.M.)
Doon Star	(E.M.)	Majestic	(E.M.)	Ulster Tarn	(E.M).
Duke of York	(F.E.)	Ninetyfold	(F.E.)	Vanguard	(F.E.)
Dunbar Rover	(S.E.)				

N.B. – *Anmerkungen – Nota:*
F.E. = first early – *früh* – *précoce*
S.E. = second early – *mittelfrüh* – *mi-précoce*
E.M. = early maincrop – *mittelspät* – *mi-tardif*
L.M. = late maincrop – *spät* – *tardif*

TABELLE *Sorten wobei Zysten auf den Knollen beobachtet wurden*
TABLEAU *Variétés sur les tubercules desquelles des kystes ont été observés*

No cyst development on the tubers was recorded in the varieties *Conference*, *Dr. McIntosh*, *Orion*, *Stormont Dawn*, *Ulster Knight* and *Up-to-Date*. It is unlikely that this implies resistance but is rather an indication of the difficulty in finding cysts where the eelworm population in the soil is at a low level.

The trial at Pentlandfield and the results of the survey have shown that Potato Root Eelworm can probably develop on the tubers of all the important commercial varieties.

3. *Seasonal Development*

Because of its possible significance in washed seed, the eelworm content of mature tubers at harvest is of some considerable importance. To determine this and the pattern of cyst development throughout the season, observations were made on the tubers of forty-four varieties planted in the infested plot at Pentlandfield on 6th and 7th May, 1958.

The tubers were examined in the field and in the laboratory. As yellow and brown cysts are readily dislodged from the roots and can remain adhering to the damp surface

of the newly lifted tubers a hand lens was used in the field observations to confirm that the head of the cyst was fully inserted into the tuber tissues. The internal eelworm population was determined by microscopic examination of the stained peel. Two tubers were selected from each plant and the outer skin peeled off with a knife. The peelings were then stained in 0,1 % cotton blue in lactophenol and cleared in phenol for examination (GOODEY, 1957).

First Earlies. Two varieties were examined two months after planting and although white cysts were present on the roots no cysts had emerged from the developing tubers. Microscopic examination of the stained peel showed young stages of Potato Root Eelworm in each variety.

One plant from each of the thirteen varieties was lifted three months after planting and white or yellow cysts were found on some tubers from each plant but in the laboratory developing eelworms were found within the tubers of five varieties only.

When the final field examination was carried out in mid October, i.e., five months after planting, it was found that three varieties had rotted following blight attack, the tubers of seven varieties were free from cysts, and a few white and yellow cysts were present on the tubers of the three remaining varieties. Two tubers from each variety were peeled and stained. One larva was found in the variety *Di Vernon* but no young stages were found in the other varieties.

Second Earlies. Two months after planting young stages were present within the tissue of the developing tubers, but none had emerged above the tuber surface. A month later, white cysts were observed on some tubers of all six varieties but only in two varieties were young stages found within the tissues. At harvest all tubers were free from white cysts but a few yellow cysts were noted on the tubers of one variety. No young stages were found within the stained peel.

Early Main Crop. Two months after planting young stages were present within developing tubers but none had emerged. After four months, white or yellow cysts were present on some tubers in five varieties but no cysts were found on the remainder, nor were developing eelworms present within the tuber tissues. At harvest a few white and yellow cysts were found on two varieties but no young stages were found within the tissues.

Late Maincrop. The tubers were very small when examined at two months but a few larvae were found within the tuber tissues. At four months after planting white or yellow cysts were found on a few tubers of all but one variety examined but no developing cysts were found within the tubers. At harvest a few white and yellow cysts were present on tubers of three varieties but no young stages were found within the stained peel.

These observations suggest that Potato Root Eelworm develops most freely on the tubers early in the season and that as the tubers mature the number of developing cysts decreases. Though fewer cysts are found late in the season they may still be numerous. DUNNETT (1957) for example recorded seventy-one cysts on one ware sized tuber lifted in late September.

4. *Biology*

In the early part of the growing season, when the tubers are first formed, the outer cells of the young tubers have living contents. The larvae enter such cells and initially single larvae may be found curled up within a cell. Later they penetrate the cell wall and move through the cells for a short distance, feeding as they go. As the tuber matures the outer cells become devoid of contents and this results in the larvae entering a lower layer in search of food. Developing eelworms have been found in the outermost cells and to a depth of three cells from the surface.

As the nematode swells, movement is restricted and in some preparations a nematode was observed lying in empty cells with its head projecting downwards into living cells. It has been suggested that the neck region of cysts which develop on tubers is on average longer than that of cysts which develop in roots. This point has not been investigated so far, but if it is so, the need to keep in contact with the receding food supply is a possible explanation.

The cells surrounding the head of the developing cyst are filled with brownish debris and may be slightly larger than normal but there is no formation of „giant" cells as occurs in the roots. In some specimens a tendency to cell proliferation was noted in the epidermal cells near the tail region of the nematode.

At Pentlandfield, white cysts were observed on tubers of early varieties from the beginning of August until the middle of October. This could mean that some cysts took much longer to develop than others but it seems much more likely that although the newly formed tuber is most heavily invaded, larval invasion continues throughout the season.

The further development of larvae which invade the tuber late in the season may depend on the conditions under which the tubers are stored after lifting. During the winter of 1956 white cysts were observed on the surface of tubers of the variety *Pentland Ace* taken from a clamp at Pentlandfield. These cysts may have developed from larvae which entered the tuber before harvest or it is possible that the attack took place in the clamp. At East Craigs there has been no evidence of cyst emergence from tubers kept in dry conditions but the emergence of white cysts has been observed by COOPER (1956) when tubers were kept in a humid atmosphere in the laboratory.

All nematodes found so far have been in the outer skin or corky tissues of the potato, *i.e.* the region formed by the cork cambium. One male specimen free from its last larval cuticle, and on several occasions ensheathed males, have been recorded within these tissues during the examination of stained peel but no fully mature female cysts.

A few cysts which had developed to maturity on tubers have been examined microscopically and found to contain eggs which looked normal but no viability tests have been carried out on these so far. DUNNETT reported that cysts formed on tubers contained fewer eggs than those which developed on the roots.

The knowledge that cysts can develop to maturity on potato tubers suggested the possibility of rearing single larvae to determine whether or not parthenogenesis was possible. Sixty boiling tubes, half filled with damp sand, were sterilised in an autoclave and a piece of cut tuber inoculated with a single larva was placed in each tube. The ex-

periment was repeated twice but no cysts developed. FASSULIOTIS (1957), experimenting with single larvae of Potato Root Eelworm on tomato roots, demonstrated that, in the absence of males, the females proceeded normally to the fifth stage and cyst formation but no embryonated eggs were produced. ELLENBY (1957) and WILLIAMS (1957), the former observing single larvae on potato roots and the latter on cut tubers, both came to the conclusion that parthenogenesis was not possible.

It appears that the life cycle in the tuber is similar in most respects to that in the root. The larvae penetrate the tissue, develop, burst through to the surface as white cysts, are fertilized, mature and drop off into the soil.

5. *The effect of tuber washing*

Yellow and brown cysts are readily dislodged from a tuber and can often be removed by quite gentle washing under a running tap. White cysts are attached to the tuber much more securely. However if tubers bearing white cysts are stored overnight in a dry atmosphere, or even at times in a humid atmosphere, the cysts tend to turn brown, lose their firm attachment and are then easily removed.

The results of the first trial carried out at a commercial washing plant have been published (MABBOTT, 1956). It was shown that tubers of the variety *Kerr's Pink* grown in an infested field could be washed so that all tubers which would be graded as seed were completely free from adhering soil. The tubers were stored in warm moist, warm dry, cold moist and cold dry, conditions and when examined at intervals during the winter were found to be free from cysts. At that time it was thought that the development of cysts on the tubers was an uncommon occurrence and, therefore, it was considered that the tubers had not been attacked by Potato Root Eelworm in the field. Investigations since then have shown that such attack and development is common.

In October, 1957 approximately $\frac{1}{2}$ cwt. of several varieties grown in the infested plot at Pentlandfield were lifted and washed within twenty four hours. The tubers before washing were seen to have white, yellow and brown cysts. After washing, each tuber was examined and they were found to be free from soil and emerged cysts. The tubers were then stored in dry conditions and no further emergence of cysts was noted during the winter. Samples were peeled and stained and no young stages were found within the tissues. Subsequent observations on washed tubers from infested land have confirmed these findings.

DISCUSSION

It has been shown that if potatoes are so washed that all adhering soil is removed, all cysts which have developed in the tuber and subsequently emerged above the surface will be removed also. It is of course necessary for the tubers to be carefully dressed and all tubers removed which have deep narrow cracks or holes resulting from mechanical damage or pest attack, as such cavities are liable to retain soil. For efficient soil removal it has been found that washing should normally be done within one or two days after lifting. If tubers from a heavy clay soil are clamped first and then washed, the soil

adheres tenaciously and may prove almost impossible to remove. In Holland it has been found that presoaking is useful in the removal of soil which has dried on the tubers.

The term „embedded" cysts has caused some confusion as it suggests that the cysts are confined within the tissue as root-knot nematodes are confined within a galled root. OOSTENBRINK (1950) stated that in an experiment in which five peeled tubers of the variety *Record* were subjected to larval attack, some of the cysts which developed were completely buried in the flesh of the tuber. Recently, in a private communication, he stated that in his belief these cysts would have emerged normally at maturity. In the present observations, which have involved the examination of stained peel from over two hundred tubers, no *fully developed* female cysts have been found within the tissues. It is possible that larvae could enter the deeper tissues, perhaps as a result of mechanical or insect damage, and become truly embedded but nothing of this nature has been seen during the investigation.

Experience in commercial plants has shown that only mature tubers can be washed successfully. Immature tubers are more susceptible to mechanical damage and also to chemical damage when disinfectant tanks are used. They are also more susceptible to bacterial soft rots. It has been shown that mature tubers from a light infestation can carry few cysts. Cysts present on the surface will be removed by a suitable washing process. If after washing the tubers are dried and stored in dry conditions, it is unlikely that any young stages which then emerge will escape desiccation. Also, it is unlikely that a male eelworm could travel far over the dry surface of the tuber to effect fertilization. Unfertilized females can be considered as non-viable.

At the present state of our knowledge, the washing of tubers from heavily infested soil cannot be recommended because with a greater number of cysts present there is more chance for a few to escape desiccation and with a higher density the distance a male may have to travel to find and fertilize a female is decreased.

CONCLUSIONS

It is considered that the principle of washing is sound for light infestations. If attention is given to the points mentioned above, the danger of Potato Root Eelworm spread in washed seed is very slight indeed. Furthermore, if consignments from land declared eelworm-free as a result of soil sampling and crop inspection are thoroughly washed, they can be given a guarantee of complete freedom from Potato Root Eelworm.

It is certainly not suggested that washing should replace soil sampling and crop inspection. The washing process is of considerable value in protecting the interests of the customer but should not be used to encourage the growing of potatoes in infested land, especially in the seed areas, as this could lead to disastrous increases in the eelworm population.

ACKNOWLEDGEMENTS

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SUMMARY

The development of Potato Root Eelworm on the tubers and stolons is a common occurrence on most potato varieties grown in infested soil. The life cycle of the eelworm in the tubers is in most respects similar to that in the roots and no fully mature female cysts have been found embedded within the tissues. Immature tubers are more heavily infested than those which are mature.

If tubers are washed in such a manner that all soil is removed, all emerged cysts are removed also. No further cyst emergence has been noted from tubers which were dried after washing and then stored in dry conditions but, even if such emergence is possible, the changes of fertilization are slight.

Complete freedom from Potato Root Eelworm can be guaranteed if consignments from land declared free by sampling methods are thoroughly washed. The risk of spread of Potato Root Eelworm on washed tubers from lightly infested land is certainly no greater than the risk of spread on unwashed consignments from fields in which the eelworm population was too light to detect at soil sampling and crop inspection.

ZUSAMMENFASSUNG

BEOBACHTUNGEN ÜBER DIE ENTWICKLUNG DER WURZELNEMATODE *H. rostochiensis* WOLL. AUF DER KARTOFFELKNOLLE UND DIE BEDEUTUNG EINER SOLCHEN ENTWICKLUNG FÜR DIE VERBREITUNG DIESER NEMATODE AUF GEWASCHENEN KNOLLEN

Die Entwicklung von Wurzelälchen auf Knollen und Stolonen ist bei den meisten in verseuchtem Boden gepflanzten Kartoffelsorten eine normale Erscheinung. Der Lebenszyklus des Älchens in den Knollen ist im wesentlichen demjenigen in den Wurzeln ähnlich und voll ausgereifte weibliche Zysten sind nicht im Gewebe eingebettet gefunden worden. Unreife Knollen sind stärker befallen als reife.

Wenn Knollen derart gewaschen werden, dass alle Bodenreste entfernt werden, werden alle Zysten ebenfalls entfernt. Bei Knollen, die nach dem Waschen getrocknet und sodann trocken gelagert wurden, wurde kein weiteres Entstehen von Zysten beobachtet, aber selbst wenn dies möglich wäre, ist die Befruchtungsmöglichkeit nach Ausschlüpfen gering.

Eine völlige Freiheit von Kartoffelwurzelälchen kann gewährleistet werden, wenn Kartoffeln aus Boden, der auf Grund von Probenentnahmen älchenfrei erklärt worden ist, gründlich gewaschen werden. Die Gefahr der Verbreitung von Älchen auf gewaschenen Kartoffeln aus leicht verseuchtem Boden ist zweifellos nicht grösser als die Gefahr der Ausbreitung auf ungewaschenen Partien aus Feldern, in denen die Älchenpopulation zu gering war, um bei der Bodenprobeentnahme und der Ernteprüfung entdeckt zu werden.

RÉSUMÉ

OBSERVATIONS SUR LE DÉVELOPPEMENT DU NÉMATODE DORÉ (*H. rostochiensis* WOLL.) SUR LES TUBERCULES DE POMME DE TERRE ET IMPORTANCE DE CE DÉVELOPPEMENT EN CE QUI CONCERNE LA PROPAGATION DU NÉMATODE SUR LES TUBERCULES LAVÉS

Le développement du nématode doré de la pomme de terre sur les tubercules et stolons est chose courante dans la plupart des variétés de pommes de terre cultivées dans un sol infecté. Le cycle vital du nématode dans le tubercule ressemble sous bien des rapports à celui dans les racines, et l'on n'a encore jamais trouvé de kystes femelles entièrement mûrs logés à l'intérieur des tissus. Les tubercules non mûrs sont plus fortement atteints que les tubercules mûrs. Si les tubercules sont lavés de manière à être complètement débarrassés du sol adhérent, tous les kystes sont enlevés en même temps. Il n'a pas été constaté d'apparition de nouveaux kystes une fois que les tubercules lavés avaient été séchés et conservés à l'abri de l'humidité; mais, quand même l'apparition de kystes serait possible, les chances de fécondation après la sortie seraient minimes.

L'absence absolue du nématode doré peut être assurée en lavant bien la récolte de champs considérés comme exempts de nématodes suivant la méthode d'échantillonnage. Les risques de propagation du nématode doré à partir du tubercule lavé provenant d'un champ légèrement infecté ne sont certainement pas supérieurs aux risques de propagation par des tubercules non lavés provenant de champs où la population de nématodes était trop faible pour être dépistée par échantillonnage du sol ou par examen de la plantation.

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OBSERVATIONS ON THE TEMPERATURES OF POTATOES PASSING TROUGH HEAT DRIERS

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Summary, Zusammenfassung, Résumé, p. 249

INTRODUCTION

Washing potatoes before retail sale has become a widespread practice in the United Kingdom. Surplus water is normally removed from the tubers by passing them over absorbent rollers of either sponge rubber or plastic, though some packers prefer to use infra-red radiation or heated air. The washed and dried potatoes are commonly sold in small polythene bags containing either three or five pounds weight.

The observations reported in this paper were made as a consequence of the concern expressed by some members of the potato trade at the rise in temperature to which tubers were subject while passing through heat driers and at the effect which this rise might have on keeping quality.

NIELSON (1946) reported from North Carolina that potatoes which attained a temperature of 92 °F or more at a depth of 1 cm below the skin were severely affected by soft rot. In a small, unreplicated, laboratory experiment using potato slices inoculated with a bacterial suspension, the combinations of temperature and exposure time which he considered to be critical were 123,8°–127,4 °F for 10 min., 113°–116,6 °F for 30 min., and 109,4°–113 °F for 60 min. Field trials in which potatoes were subjected to these time/temperature combinations did not, however, entirely support the laboratory experiments.

ROSE and SCHOMER (1944) had previously reported that in all cases where the temperature 1/16th in. below the skin of a potato tuber had been raised to 130 °F, and in some cases where it had been raised to 125 °F, typical symptoms of sun scald appeared – namely, blackening of the flesh and the appearance of exudate at the lenticels. Bacterial soft rot always followed when potatoes so affected were subsequently stored at 90 °F, unless the tubers had been previously sterilized and maintained thereafter in a sterile condition. Later, ROSE and COOK (1949) summarized the American work on heat injury by saying that „Heat damage may be expected whenever the potatoes are exposed to the sun for 15 min. or longer on days when the air temperature is 90 °F or higher" and that „Heat damage is likely to occur when the surface temperature is 110 °F or higher".

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From this last statement, it might be supposed that such damage would frequently occur in drying machines in which a relatively small volume of air is heated to a temperature approaching 250 °F, in contradistinction to other machines utilizing a large volume of air warmed at only 140°–145 °F. The cooling effect of the evaporating moisture must be taken into account, however, in making any such supposition.

EXPERIMENTAL WORK

The work recorded in this paper was confined to the measurement of tuber temperature alone: it was not concerned with the thermal efficiency of the two types of machine or with the economics of their use. Both types were operated at the capacity rate approved by their makers, the rate in each case being such that although the tubers were still damp after emergence from the machine they were completely dry by the time they were packed.

The "high" temperature machine. This machine (a Greenbank, manufactured by Messrs. P. J. EDMONDS) was 12 ft long; potatoes were carried through it on a roller conveyor which ensured that they were turned over and over continuously during the drying process. An 18 ft long roller sorting table was arranged to convey the output of the drier to the bag filling machinery, after the removal by hand of diseased or damaged tubers. The outstanding feature of this drier was the method of air circulation employed: most of the air in the machine was re-circulated, a relatively small proportion only of fresh, unheated, air being drawn in by the fan. The air left the electric heater bank at a temperature of 235 °F; the temperature of the air among the potatoes on the central portion of the drying conveyor was 195 °F.

It will be seen from TABLE 1 that tubers passed through this machine in 60 seconds. The maximum temperature was recorded 30 sec. after the potatoes had left the machine, by which time they had travelled some 6 ft along the sorting conveyor. The mean maximum tuber temperature (11 observations) at 1 mm depth below the skin was 95 °F; the absolute maximum observed was 104 °F. TABLE 1 shows also that the rise in temperature at 7,5 mm depth below the surface was 20 °F at the most; at the centre of the tuber the rise was very slight indeed, amounting to no more than 2 °F. It is of interest that the tubers cooled rapidly, once the maximum had been reached – the temperature at 1 mm depth dropping by 20 °F in 60 seconds (see FIG.).

At this experimental centre, temperature observations were continued for 18 hours on one individual commercial pack comprised of 18 × 3 lb. perforated polythene packs in a triple wall kraft paper bag: this container was filled 90 sec. after the tubers had emerged from the drying machine. Potatoes in the centre of the container (which was kept surrounded by others of a similar nature) cooled slowly and steadily by a further 10 °F during the 18 hours following packing, after which interval the observations were discontinued.

The "low" temperature machine. This drier, too, (manufactured by LOCKWOOD GRADERS Inc.) was 12 ft long and incorporated a roller conveyor to ensure that the

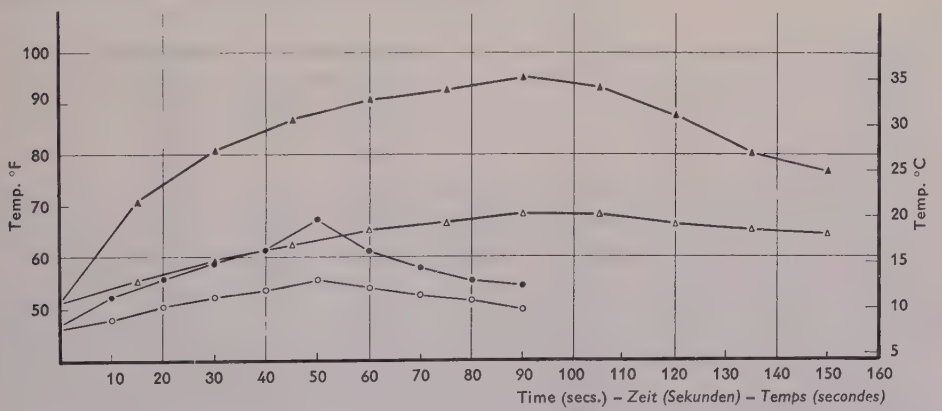
TABLE 1. Recorded tuber temperatures in °F; the "high" temperature machine

Travel in – *Trajekt in – trajet en*		Depth of thermocouple below skin – *Tiefe des Thermoelements unter der Schale – profondeur du thermocouple sous la pelure*					
		1 mm		7,5 mm		Centre – *Mitte – centre*	
Distance *Abstand Distance* Feet – *30 cm*	Time *Zeit Temps* sec. – *Sek. – sec.*	Mean *Mittel Moyenne* (1)	S.D. *S.a. écart-type* ±	Mean *Mittel Moyenne* (2)	S.D. *S.a. écart-type* ±	Mean *Mittel Moyenne* (3)	S.D. *S.a. écart-type* ±
0	0	51,4	0,3	51,0	0,6	49,5	–
3	15	70,8	5,8	55,2	1,7	49,8	–
6	30	80,7	5,8	59,0	0,7	50,3	–
9	45	86,5	8,1	62,2	1,5	50,6	–
12	60	90,4	7,8	65,0	2,0	51,5	–
15	75	92,3	7,2	66,9	2,0	51,5	–
18	90	95,0	7,6	68,3	1,4	51,9	–
21	105	88,2	5,7	68,1	1,8	51,5	–
24	120	82,6	4,0	66,5	1,1	51,1	–
27	135	80,2	4,2	65,4	1,3	51,1	–
30	150	76,8	2,8	64,5	1,4	51,1	–

(1) 11 observations; mean max. 95°, absolute max. 104° – *11 Beobachtungen; Durchschnittsmax. 95°, abs. Max. 104° – 11 observations; max. moyen 95°, max. absolu 104°.*
(2) 4 observations – *4 Beobachtungen – 4 observations.*
(3) 1 observation – *1 Beobachtung – 1 observation.*

TABELLE 1. *Registrierte Knollentemperaturen in °F; die Hochtemperaturmaschine*
TABLEAU 1. *Températures des tubercules registrées en °F; la machine à haute température*

FIGURE. Temperatures of potatoes passing through drying machines



▲ High temp.machine, 1 mm depth – *Hochtemp. Maschine, 1 mm Tiefe – Machine à haute temp., profondeur 1 mm.*
△ High temp. machine, 7,5 mm depth – *Hochtemp.Maschine, 7,5 mm Tiefe – Machine à haute temp., profondeur 7,5 mm.*
● Low temp. machine, 1 mm depth – *Tieftemp. Maschine, 1 mm Tiefe – Machine à basse temp., profondeur 1 mm.*
○ Low temp. machine, 7,5 mm depth – *Tieftemp. Maschine, 7,5 mm Tiefe – Machine à basse temp., profondeur 7,5 mm.*

ABBILDUNG. *Temperaturen von Kartoffeln beim Passieren von Trockenanlagen*
FIGURE. *Températures des tubercules traversant des séchoirs*

potatoes were turned over and over as they dried. As in the case of the Greenbank installation, a roller sorting table was arranged to convey the output of the drier to the automatic bagging machinery, after the removal by hand of blemished tubers; this sorting table was 10 ft in length. The whole of the conveyor system in the packhouse was run at a higher speed than was that at the first experimental centre, tubers passing through the drier in 48 sec. and reaching the bagging points in a further 40 sec.

None of the air in the Lockwood machine was re-circulated, the whole of the requirement being drawn through ductwork from outside the building. The temperature of the air leaving the oil-fired heat exchanger was 150 °F: the temperature of the air among the potatoes on the machine's drying conveyor was only slightly lower, varying from 140°–145 °F. From TABLE 2 it will be seen that the rise in tuber temperature was very much less than was the case in the first machine. The mean maximum tuber temperature at 1 mm depth (10 observations) was 67,3 °F, the absolute maximum 71,8 °F. The tubers again cooled rapidly, by 13 °F in 40 sec. at the 1 mm depth: even at that depth, the rise in temperature to which they had been subjected was only 20 °F, however, so that this amount of cooling was sufficient to return them to within 7 °F of their initial temperature. TABLE 2 shows also that the rise in temperature was less than 10 °F at the 7,5 mm depth and only 1 °F at the tuber centre.

TABLE 2. Recorded tuber temperatures in °F; the "low" temperature machine

Travel in – *Trajekt in – trajet en*		Depth of thermocouple below skin – *Tiefe des Thermoelements unter der Schale profondeur du thermocouple sous la pelure*					
Distance *Abstand Distance* Feet – *30 cm*	Time *Zeit Temps* sec. – *Sek. – sec.*	1 mm		7,5 mm		Centre – *Mitte – centre*	
		Mean *Mittel Moyenne* (1)	S.D. *S.a. écart-type* ±	Mean *Mittel Moyenne* (2)	S.D. *S.a. écart-type* ±	Mean *Mittel Moyenne* (3)	S.D. *S.a. écart-type* ±
0,0	0	47,0	1,1	46,2	1,7	41,9	0,2
2,5	10	52,0	2,4	47,9	1,7	41,9	0,2
5,0	20	55,7	3,0	50,1	1,8	42,1	0,2
7,5	30	58,9	3,0	52,2	2,6	42,3	0,2
10,0	40	61,1	2,8	53,5	3,3	42,5	0,3
12,5	50	67,3	2,7	55,4	3,5	42,8	0,4
15,0	60	61,2	3,7	53,9	2,8	42,9	0,3
17,5	70	57,8	2,2	52,4	2,4	42,6	0,4
20,0	80	55,3	1,7	51,2	2,3	42,3	0,2
22,5	90	54,3	1,7	49,9	1,6	–	–

(1) 10 observations; mean max. 67,3°, absolute max. 71,8° – *10 Beobachtungen; Durchschnittsmax. 67,3°, abs. Max. 71,8° – 10 observations; max. moyen 67,3°, max. absolu 71,8.*
(2) 10 observations – *4 Beobachtungen – 4 observations.*
(3) 3 observations – *3 Beobachtungen – 3 observations.*

TABELLE 2. *Registrierte Knollentemperaturen in °F; die Tieftemperaturmaschine*
TABLEAU 2. *Températures des tubercules registrées en °F; la machine à basse température*

CONCLUSION

It may be concluded that the maximum temperature likely to be reached by tubers when they are passed through either of the two types of machine described is not high enough to cause heat damage. Of 92 commercial packs filled with potatoes dried by the machines, 9 were found to contain one or more tubers affected by soft rot after storage periods of between 12 and 25 weeks: in each case it was evident from the appearance of the rot that the infection was an old one, almost certainly initiated before the tubers were washed and packed. Neither amongst these packs, nor amongst a large tonnage packed commercially, was anything seen which suggested that the drying operation had increased the susceptibility of the tubers to soft rot infection, or in any other way decreased their storage life.

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SUMMARY

This paper reports observations made on the extent and duration of the rise in temperature of potatoes passed through heat driers of two types. In neither drier was the maximum temperature likely to be reached high enough to cause heat damage.

ZUSAMMENFASSUNG

BEOBACHTUNGEN ÜBER DIE TEMPERATUREN VON KARTOFFELN BEIM DURCHGANG DURCH WÄRMETROCKNER

In diesem Bericht werden Beobachtungen über Umfang und Dauer der Temperatursteigerung bei Kartoffeln beim Durchgang durch Wärmetrockner beschrieben. Bei keinem der Trockner war die wahrscheinlich erreichte Temperatur hoch genug, um Schädigung durch Hitze zu verursachen.

RÉSUMÉ

OBSERVATIONS SUR LA TEMPÉRATURE DES POMMES DE TERRE PENDANT LEUR PASSAGE DANS DES SÉCHOIRS A CHAUD

Le présent article fournit un exposé d'observations relatives à l'importance et à la duré de l'augmentation de la température des tubercules traversant deux types de séchoirs à chaud. Ni dans l'un, ni dans l'autre séchoir, le maximum probable de la température n'était assez élevé pour pouvoir endommager le produit.

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FIELD TRIALS ON THE RETENTION OF POTATO STOCKS IN ENGLAND

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INTRODUCTION

Since the early 1930's British potato stocks have improved greatly in health, and especially in freedom from virus diseases, because the regulations for the certification of seed tubers have been made more stringent and ware-potato growers usually buy new "certified" seed every year or other year. Today nearly two-thirds of the ware (table-stock) acreage in England is planted with certified seed and almost all the rest is "once-grown", i.e. in the second year on that particular farm or in a ware-growing area. New certified seed is expensive and may account for about one-third of the cost of growing the crop, so ware-potato growers might decrease this cost if they could grow their stocks for three, four or more years instead of for one or two (BROADBENT, BURT & NIX, 1957).

Experiments with replicated small plots done at Rothamsted since 1949 show that efficient aphicides, applied to a potato crop four or more times beginning soon after the plants emerge through the ground, stop leaf roll virus spreading and check the spread of virus Y (which causes the disease rugose mosaic) by killing the aphids that spread these viruses (BROADBENT, BURT & HEATHCOTE, 1956; 1958). The proximity of unsprayed to sprayed plots in these experiments probably decreased the beneficial effect of spraying and this bias was further increased by surrounding each plot with a strip of unsprayed healthy potatoes which could be a source of aphids but not of viruses.

METHODS

To find whether the results obtained at Rothamsted apply to field crops and in other parts of England, where patterns of aphid movement and virus spread might differ, several trials were arranged in co-operation with officers of the National Agricultural Advisory Service (N.A.A.S.) and with potato growers. To avoid the bias in the small plot trials it was desirable to take two similar fields in each area, allocating at random

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one to be sprayed and one unsprayed. Several trials of this kind were started, but the unsprayed controls had to be abandoned in areas where viruses spread rapidly because infection not only led to loss of crop, but to danger that dispersing aphids would carry viruses to other potato crops. Several growers refused from the first to grow an unsprayed stock for more than one year.

It was, therefore, necessary to seek indirect evidence by using aphid trap catches in many of the trials to indicate whether conditions would have favoured spread had the crops not been sprayed. This is possible because virus spread in standardized experiments was previously correlated with the numbers of winged *Myzus persicae* SULZ. trapped in unsprayed potatoes during the season (BROADBENT, 1950; HOLLINGS, 1955). The traps (BROADBENT, DONCASTER, HULL & WATSON, 1948) were operated in unsprayed potatoes near to sprayed plots and some idea of what the spread would have been was obtained from the numbers of *M. persicae* caught, combined with knowledge of the spread that occurred each year in the unsprayed control areas of statistically designed experiments done at Rothamsted (BROADBENT *et al*, 1956, 1958), Lymington (BROADBENT, HEATHCOTE, BROWN & WHEELER, 1960) and Sprowston (see below).

Growers were asked to plant about two acres of certified seed and to spray and retain seed from this stock to plant a similar acreage during later years until the stock contained up to 10% infected plants. Stocks were usually renewed before this. Plants showing symptoms of leaf roll or rugose mosaic were rogued (removed) in a few trials either by N.A.A.S. officers or by us. When the sprayed area could not be isolated from other potato crops, growers were asked to place it among unsprayed healthy potatoes. They were recommended to spray the remainder of their stocks once during early July to decrease the number of summer migrant aphids, which may carry virus from one crop to another during July and early August. The aphids on sprayed and unsprayed plants were counted several times during each season to check the efficiency of the spraying. The counts are not quoted because past experience shows that they are less related to virus spread than are the trap catches.

Guided by conclusions drawn from the Rothamsted experiments, most growers used proprietary brands of DDT emulsion applied at either high or low volume at the rate of 2 lb. of active ingredient per acre until the potatoes ceased growing rapidly, after which 1 lb. per acre was applied. The other insecticide used occasionally was demeton-methyl ("Metasystox"). The importance of applying the first spray when about 75–90% of the plants had emerged was stressed. The plants are then most susceptible to infection by viruses and aphids are best able to acquire virus from infected plants within the crop.

RESULTS

Introduction of virus into healthy crops

Those trials which were planted with healthy stocks are listed in TABLE 1 together with the incidence of leaf roll or rugose mosaic in them the following year. In 12 trials where seed was saved from unsprayed potatoes adjoining the sprayed, disease inciden-

TABLE 1. Incidences of disease due to virus introduced into healthy stocks during their first year in England

Year *Jahr Année*	Site – *Lage – Localité*	Variety *Sorte Variété*	*M. persicae* trapped *gefangen capturés*	Leafroll *Blattroll enroulement* % S[1]	Leafroll % U[2]	Rugose mosaic *Kräuselmosaik frisolée* % S[1]	Rugose mosaic % U[2]
1952	Essex, Clavering	King Edward	10	1,2	1,1	2,6	2,1
1953	Essex, Harlow	King Edward	377	3,7	4,1	0,05	0,05
	Herts., Rothamsted	Majestic	148		1,6		0
1954	Glos., Badminton	Arran Pilot		0	0	0,1	0,5
	Glos., Elkstone	„ „		0,01	0,2	0,02	0,1
	Hants., Lymington	Ulster Prince	7	0,2		0,03	
	Herts., Rothamsted	Majestic	8		1,0		0,4
1955	Berks., Drayton	Majestic	12	1,0		6,0	
	Cambs., Guyhirn	King Edward	125	0,4	0,1	0,1	0,2
	Cornwall, Redruth	Arran Pilot	3	0		0	
	Durham, Bish. Auckland	Arran Peak		0	0	0,2	0,2
	Essex, Chelmsford	King Edward	31	0,7		2,8	
	Essex, Corringham	Majestic	21	0,5		0,6	
		Red King		0,1		1,0	
	Essex, Hatfield Peverel	„ „		0,3		0,9	
		„ „		0,1		0,4	
	Essex, West Mersea	King Edward	65	1,1		0,4	
	Essex, West Thurrock	Home Guard		2,3		20,7	
	Essex, Writtle	King Edward		0,5		3,9	
	Herts., Rothamsted	Majestic	105		0,4		0,7
	Lincs., Grainsby	„	54	0	0	0	0
	Norfolk, Sprowston	King Edward	13	0,2	0,3	0,2	0,3
	Yorks., High Mowthorpe	„ „	22	0	0	0	0
1956	Cornwall, Redruth	Arran Pilot	6	2,4		0	
	Herts., Rothamsted	Majestic	72		1,3		0
	Lincs., Long Sutton	King Edward	136	0,1	0,4	0	0
	Northants., Peterborough	Majestic		0,1		0,1	
		King Edward		0,2		0,1	
	Yorks., Hemingbrough	Majestic		0		0	
	Yorks., Nigh Mowthorpe	King Edward (2nd year)	6	0	0	0	0
1957	Essex, Harlow	King Edward	35	1,5		3,5	
	Herts., Rothamsted	Majestic	121		3,2		7,6
	Northants., Peterborough	King Edward	285	0,5		0,2	
1958	Herts., Rothamsted	Majestic	16		0		0

[1] Sprayed – *gespritzt – pulvérisé.*
[2] Unsprayed – *nicht gespritzt – non pulvérisé.*

TABELLE 1. *Auswirkung der Krankheiten verursacht durch das in gesunde Pflanzungen in England im ersten Anbaujahre eingeführte Virus*

TABLEAU 1. *Incidence des maladies causées par le virus, introduit dans des plantations saines en Angleterre pendant leur première année*

ces in both stocks the next year were similar, indicating that spraying did not prevent aphids that were already infective when they entered the crop from infecting plants. This was expected, for aphicides applied to plants usually take at least an hour to incapacitate an aphid.

In only five trials was no virus introduced; more leaf roll than Y was introduced into eleven trials, and more Y than leaf roll in 13. Although evidence is given later that crops can, occasionally, be seriously infected by aphids during their summer dispersal, the most obvious conclusions from these results are that usually few plants are infected by summer migrants because the health of most potato crops on which they developed is good, which reflects credit on the seed certification schemes. The high incidence of rugose mosaic at West Thurrock, Essex, may be typical of areas in which market garden crops and early potatoes are grown: stocks are normally grown for two years because once-grown crops yield earlier than new stocks; aphids readily survive the winter and virus Y is carried from the once-grown to the new stocks.

Virus spread during the years 1954–1959

Experiments on the control of virus spread were done each year at Rothamsted, starting with about 0,8 % of tubers in each plot infected with leaf roll virus and 0,8 % with virus Y. TABLE 2 shows the catches of *M. persicae* in nearby unsprayed potatoes, and the factors by which the diseases increased, as calculated from samples from each unsprayed plot grown the next year. Similar results were obtained from the Lymington and Sprowston experiments.

Although these experiments were done with small replicated plots and under different conditions at the different places, they confirm past experience that when *M.*

TABLE 2. Disease increase in unsprayed plots during 1954–58

		M. persicae trapped – *gefangen* – *capturés*	Factors by which increased[1]	
			Leaf roll	Rugose mosaic
Rothamsted	1955	105	× 15,3	× 13,6
	1956	72	× 7,4	× 4,9
	1957	121	× 25,0	× 44,2
	1958	16	× 5,2	× 3,5
Lymington	1954	7	× 4,2	× 2,1
	1955	12	× 26,8	× 7,9
	1956	43	× 12,7	× 7,1
Sprowston	1956	144	× 7,0	× 0
	1957	46	× 6,3	× 51,0

[1] *Erhöhende Faktoren für Blattroll bzw. Kräuselmosaik – facteurs d'augmentation de l'enroulement et de la frisolée.*

TABELLE 2. *Krankheitszunahme in ungespritzten Parzellen 1954–1958*
TABLEAU 2. *Augmentations des maladies dans des parcelles sans pulvérisation en 1954–1958*

persicae are numerous, especially during May, June and July, the incidences of both diseases can be expected to increase by at least five times. If viruses do not spread in sprayed plots when aphids are numerous, it is reasonable to conclude that this is a result of the treatment.

Stocks retained for three years or longer

Several unreplicated trials were done in potato-growing areas where *M. persicae* are usually numerous and where viruses were expected to spread rapidly. The farmers normally bought new seed stocks every one or two years but the sprayed stocks provided profitable crops for three or four years (TABLE 3). The Peterborough and Guyhirn stocks could have been grown for a fifth year and the Long Sutton one possibly for several more years.

Aphids became very numerous during September 1957 at both Guyhirn and Peterborough (3320 aphids per 100 leaves on 5 September) after spraying had stopped in mid-July, but they did not spread virus to many plants. The high incidence of leaf roll (9%) at Corringham (Essex) in 1958, and the low incidence of rugose mosaic, suggest that leaf roll virus had been introduced, for had it been spread within the crop virus Y would probably have spread also.

Several other trials were done in areas where aphids are usually few and which, in consequence, might be suitable for growing seed potatoes with or without aphid control by spraying (TABLE 4). Despite adequate spraying, in 1956 virus Y infected many plants in both sprayed and unsprayed Badminton stocks, and leaf roll and Y viruses infected the Elkstone stocks.

The trial at Penallt (Monmouth) was done in an area at present eligible for the production of certificate "A" seed. During 1957 virus Y was introduced into the crop by aphids; had spread been within the crop, more leaf roll virus would have been expected. In 1958 rugose mosaic was prevalent and about 70% of the tubers proved to be infected with virus Y when grown in 1959. The trial near Redruth (Cornwall) started in 1955 with a stock of *Arran Pilot* that had been grown unrogued and unsprayed for six years in an area on Dartmoor approved for growing stock seed and was still healthy. Aphids were very few each year but leaf roll was introduced in 1956 and because spraying did not start until 2 to 6 weeks after the plants had emerged in the different years, it increased to nearly 4% in 1958.

Where aphids were few spraying did not appreciably prolong the life of the stocks, and the trials confirmed previous inferences that spraying does not prevent viruliferous aphids from infecting plants when they invade a crop.

Replicated experiments on degeneration

Two experiments were done to study the increase in virus disease in crops initially free from virus-infected plants and to find whether spraying prolonged the useful life of the stocks. A secondary aim was to find the best times to spray. In both experiments five treatments were tested in 1/5 acre plots in a Latin Square, planted with an "A" stock of the variety *King Edward*, as follows:

TABLE 3. Spraying treatments, *M. persicae* trapped, and disease incidences in trials in areas where *M. persicae* were numerous

Site – *Lage – Localité*	Variety *Sorte Variété*	Year *Jahr Année*	Spray *Spritzung Pulvérisation*	*M. persicae* trapped *gefangen capturés*	Leaf roll *Blattrol*[1] *enroulement* % S[1]	Leaf roll % U[2]	Rugose mosaic *Kräuselmosaik frisolée* % S[1]	Rugose mosaic % U[2]
Cambs., Guyhirn	King	1955	DDT HV/L6	125	0	0	0	0
	Edward	1956	DDT HV5	235	0,4*	0,1	0,1*	0,2
		1957	MS HV1 DDT HV2	121	0,4*	1,2	0,04*	0,5
		1958	DDT HV1 MS HV1	99	4,2		0,3	
Essex, Corringham	Red King	1955	DDT HV/L5	21	0		0	
	Edward	1956	DDT HV/L2 HV2	209	0,1		1,0	
		1957	DDT HV1	31	?		?	
		1958	DDT HV1	–	9,4		1,0	
Holland, Lincs., Long Sutton	King	1956	DDT HV/L4 HV1	136	0	0	0	0
	Edward	1957	DDT LV2 HV/L2	79	0,1*	0,4	0	0
		1958	DDT LV2 MV/L1	68	1,2*		0,1*	
		1959	DDT MV/L1	–	0,4		0,1	
Norfolk, Sprowston	King	1955	DDT MV1 HV5	13	?		?	
	Edward	1956	DDT MV/L6	144	0,2	0,3	0,2	0,3
		1957	DDT MV/L6	46	0,7	2,1	0	0,1
		1958	DDT MV/L3	–	1,5	13,3	5,3	5,1
Northants., Peterborough	King	1956	DDT MV2 HV/L2	–	0		0	
	Edward	1957	DDT MV2 HV/L1	285	0,2*		0,1*	
		1958	DDT MV1 HV/L3	59	0,6		0,2	
		1959	DDT MV1	36	3,3		1,7	
Northants., Peterborough	Majestic	1957	DDT MV2 HV/L1	285	0		0,02*	
		1958	DDT MV1 HV/L3	59	?		?	
		1959	DDT MV1	36	4,8		0,1	

[1], [2] See notes in TABLE 1 – *siehe Anmerkungen zu* TABELLE 1 – *voir notes du* TABLEAU 1.

HV – high volume, >70 gal./acre
MV – medium volume, 30–69 gal./acre
LV – low volume, <30 gal./acre
} overhead jets only.

HV – hohe Gabe >70 "gal./acre"
MV – mittl. Gabe, 30–69 "gal./acre"
LV – niedr. Gabe <30 "gal./acre"
} *nur Spritzungen der oberen Blattspreite.*

HV – forte dose > 70 "gal./acre"
MV – dose moyenne 30–69 "gal./acre"
LV – faible dose <30 "gal./acre"
} *pulvérisations seulement sur le dessus des feuilles.*

/L overhead and underleaf jets – *Spritzungen der oberen und unteren Blattspreite – pulvérisations sur le dessus et le dessous des feuilles.*

1–6 number of sprays – *Anzahl der Spritzungen – nombre de pulvérisations.*

* rogued – *kranke Pflanzen ausselektiert – épuration sanitaire.*

MS demeton-methyl (metasystox).

TABELLE 3. *Spritzbehandlungen, Zahl gefangener M. persicae und Auswirkung der Krankheiten bei Versuchen in Gebieten mit zahlreichen M. persicae*

TABLEAU 3. *Pulvérisations, nombre de M. persicae capturés et incidence des maladies dans des essais effectués dans des régions où M. persicae était nombreux*

TABLE 4. Spraying treatments, *M. persicae* trapped, and disease incidences in trials in areas where *M. persicae* were few

Site – *Lage* – *Localité*	Variety *Sorte* *Variété*	Year *Jahr* *Année*	Spray *Spritzung* *Pulvérisation*	*M. persicae* trapped *gefangen* *capturés*	Leaf roll *Blattroll* *enroulement* %		Rugose mosaic *Kräuselmosaik* *frisolée* %	
					S[1]	U[2]	S[1]	U[2]
Berks., Pusey	Arran Pilot	1955	DDT a.HV5	2	0,2*		0,3*	
			b.HV5		0,2		0,3	
			c. LV5		0,2		0,3	
		1956	DDT a.HV4	9	0	0,3	0,3*	0,8
			b.HV4		0		0,3	
			c. LV4		0		0,8	
		1957	DDT a.HV4	11	?		?	
			b.HV4					
			c. MV4					
		1958	DDT a.HV1	–	1,8		4,8	
			b. HV1		1,0		5,1	
			c. MV1		1,5		6,5	
Cornwall, Redruth	Arran Pilot	'49/54	Unsprayed, unrogued			0		0
		1955	DDT MV2	3	0		0	
		1956	MS MV2	6	0		0	
		1957	MS MV2	1	2,4		0	
		1958	MS MV2	0	3,7		0	
Durham, Bishop Auckland	Arran Peak	1955	DDT HV4	–	0,1	0,1	0	0,1
		1956	DDT HV3	–	0,2	0,1	0,2	0,3
		1957	DDT HV3	0	0,1	0,2	0	0,2
Glos., Badminton	Arran Pilot	1954	DDT HV5	–	0	0,01	0	0
		1955	DDT HV4	17	0	0	0,1*	0,5
		1956	DDT HV4	12	0,1	0,2	4,2	0,6
		1957		–	0,3	0,9	47,5	24,5
Glos., Elkstone	Arran Pilot	1954	DDT HV4	–	0	0	0	0
		1955	DDT HV4	17	0,01*	0,2	0,02*	0,1
		1956	DDT HV3	3	0,2	0,1	3,6	0,6
		1957		–	8,6	11,8	9,7	6,3
Lincs., Lindsey, Grainsby	Majestic	1955	DDT HV/L6	54	0,2	0,2	0	0
		1956	DDT HV/L7	39	0,2	0,3	0	0
		1957	DDT HV/L6	0	1,3		0	
		1958	DDT HV/L1	6	0,6		0,1	
		1959		–	0,7		0,04	
Monmouth, Penallt	Arran Pilot	1955	DDT HV/L4	19	0,1	0,1	0	0
		1956	DDT HV/L4	0	0	0,04	0	0,04
		1957	DDT MV/L2 HV/L2	1	0,01	0,04	0,05	0,09
		1958	DDT MV1 HV/L3	1	0,2	0,5	?	?
		1959		–	0	0,4	74,3	63,3

[1], [2] See notes in TABLE 1 (for explanation of abbreviations in column 4: see TABEL 3) – *siehe Anmerkungen zu* TABELLE 1 (*zur Erläuterung der Abkürzungen in Spalte 4: siehe* TABELLE 3) – *voir notes du* TABLEAU 1 (*pour explication des abréviations de la colonne 4: voir* TABLEAU 3).

TABELLE 4. *Spritzbehandlungen, Zahl gefangener M. persicae und Auswirkung der Krankheiten bei Versuchen in Gebieten mit nur wenigen M. persicae*

TABLEAU 4. *Pulvérisations, nombre de M. persicae capturés et incidence des maladies dans des essais effectués dans des régions où M' persicae était rare*

1. Unsprayed.
2. Sprayed with DDT 6 times (TABLE 5).
3. Sprayed on 2nd and 4th occasions.
4. Sprayed on 2nd occasion (mid-June).
5. Sprayed on 4th occasion (mid-July).

The experiments were done at the Agriculture Station, Sprowston, Norfolk and the N.A.A.S. Experimental Husbandry Farm, High Mowthorpe, Yorks. At Sprowston the plots in treatment 2 were sprayed soon after emergence, 10 days later and then every 14 days. Aphid control was relatively poor in 1955 when underleaf lances were not used, but was good in subsequent years when they were. Seed tubers from the five plots of a treatment were bulked and redistributed among the plots of that treatment each year.

The stock contained a few infected plants in 1955, and leaf roll virus spread each year in the unsprayed plots until, by 1958, 13,3 % of the plants were infected in contrast to only 1,5 % in plots sprayed six times (TABLE 5). *M. persicae* were few in 1956 until late July and the second spray in mid-June was less effective in stopping the spread of leaf roll virus than was the fourth in mid-July. The small samples of 1500 plants per treatment taken for disease assessment may account for the apparently low incidence of leaf roll in treatment 3 in 1957. Virus Y spread rapidly in 1957 when winged aphids were unusually numerous early; in 1958 incidence was related to that of the previous year, spraying in 1957 having failed to decrease spread. The results confirm those obtained at Rothamsted in 1955 and suggest that more than two but fewer than six sprays would be optimal.

At High Mowthorpe, in an area eligible for producing Stock Seed the stock was

TABLE 5. Average incidences of disease in plots with different treatments, Sprowston, 1956–8[1]

Treatment – *Behandlung* – *traitement*	Leaf roll % – *Blattroll in* % – *enroulement en* %			Rugose mosaic % – *Kräusel-mosaik in* % – *frisolée en* %		
	1956	1957	1958	1956	1957	1958
1. Unsprayed	0,3	2,1	13,3	0,3	0,1	5,1
2. Sprayed 6 times	0,2	0,7	1,5[2]	0,2	0	5,3
3. Sprayed 2nd & 4th occasions	0,4	0,1	3,9[2]	0,1	0,3	9,8[2]
4. Sprayed 2nd occasion	0,1	1,9	11,5	0	0	3,8
5. Sprayed 4th occasion	0,1	0,8	6,6[2]	0,4	0,9	19,1[2]

[1] Based on 2 samples of 150 tubers each per plot, i.e. 1500 per treatment – *basiert auf 2 Proben von je 150 Knollen pro Parzelle, d.h. 1500 Knollen pro Behandlung – basé sur 2 échantillons de 150 tubercules chacun, c. à d. 1500 par traitement.*

[2] Significantly different from unsprayed at 5% level – *signifikant different von ungespritzt (P 0,05) – significativement différent de non pulvérisé au seuil 0,05.*

TABELLE 5. *Durchschnittliche Auswirkung der Krankheiten in Parzellen mit verschiedenen Behandlungen in Sprowston 1956–1958*[1]

TABLEAU 5. *Incidence moyenne des maladies dans des parcelles ayant subi différents traitements à Sprowston en 1956–1958*[1]

initially healthy and no virus was introduced during the three years of the experiment, although 22 *M. persicae* were trapped during 1955, 6 during 1956 and 3 during 1957.

DISCUSSION

Although some of these trials lacked adequate controls of unsprayed fields, the results confirm the conclusion of the small-plot experiments that growers could often keep their potato stocks healthy for three, four or more years by spraying with insecticides. Although the sprays must be applied carefully and early enough, success will depend largely on whether virus Y is present and on the extent to which viruses are transmitted from one crop to another in the area. Such spread between crops would be decreased by spraying all infected potato crops with a suitable aphicide during the first half of July for this would check the development and dispersal of winged aphids.

Aphids sometimes colonize potato plants as soon as these emerge, and in such condition contact insecticides may not be fully effective. Experiments at Rothamsted in 1957 showed that in these circumstances a systemic is more effective than a contact insecticide for it is carried to aphids hidden beneath leaves near the ground; also many systemic insecticides have a fumigant action. Since 1940 there have been three springs when aphids were numerous early, and because such seasons cannot be predicted, the routine use of a systemic insecticide for the first spray is preferable. In several of the trials aphids were less well controlled by DDT when only overhead nozzles were used than when sprays were applied by both overhead and underleaf nozzles.

One reason why relatively few plants become infected during July and August, when populations of both winged and wingless potato aphids are usually maximal in England, is that plants at this time are less susceptible to infection than when they are young (Broadbent, Gregory & Tinsley, 1952). Another is that old infected plants are less effective sources of leaf roll virus than young plants (Kassanis, 1952); also, plants infected with virus Y sprawl and die early (Broadbent & Gregory, 1948). During the present trials large aphid populations sometimes developed during August and September after the last spraying, for example at Guyhirn and Peterborough in 1957; or when hot weather affected the efficiency of the insecticide as at Rothamsted and Sprowston in 1955. Although numerous, these aphids did not spread virus extensively within the crop. Experiments have not so far given any evidence that spraying after the third week of July is worth while. Four sprays between emergence and mid-July adequately protected potatoes planted during late March and April from spread within the crop.

Many potato inspectors and plant pathologists in England consider that leaf roll virus is the major cause of degeneration in potato stocks, because stocks from Scotland and Ireland sometimes contain a few tubers infected with leaf roll virus but seldom any infected with virus Y. Leaf roll is the disease most commonly seen in new or once-grown stocks, but when stocks are kept longer than this, virus Y becomes in many areas much more important. Leaf roll can be controlled by spraying and roguing, so infection with virus Y is now the principal factor limiting the retention of stocks in

England. As this virus is introduced into stocks mostly in midsummer from nearby potato fields, the need for co-operative action among growers is obvious.

The trials show that there are some areas of England where potato stocks might be kept for three or more years without spraying, although not all of them are recognized as suitable for growing certified seed. Aphids are usually few in these areas, and there is little spread of virus within crops, but some are not distant enough from "degeneration" areas from which viruses can be carried occasionally by dispersing aphids.

The results of these trials did not suggest that roguing, in addition to spraying, decreased disease sufficiently to warrant the labour involved. However, it has been worth while in a small area grown specially for seed in Hampshire (BROADBENT *et al*, 1960) and in a trial at Harlow (BROADBENT *et al*, 1958). As infected potato plants are seldom sources of virus for spread within the crop during the same season that they are infected, there is no need to spray again after thoroughly roguing.

In all these trials seed was obtained as a by-product from a ware crop. This entails spraying a large acreage, which is time-consuming and often difficult or impossible in a wet year. Although a small area grown specially for seed is slightly more costly, it has many advantages, particularly as the work is more likely to be done conscientiously. A small area is also more quickly rogued.

The financial advantages of saving seed from the ware crop or on the ware farm will vary with the relative prices for seed and ware tubers. Growers of first early potatoes are likely to find the system most profitable because home-grown seed often bulks earlier than new seed from the north.

ACKNOWLEDGEMENTS

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SUMMARY

Field trials done to supplement replicated small-plot trials showed that the incidence of leaf roll and Y viruses in potato crops remained low for several years in many parts of England when the crops were sprayed with insecticide, and in some parts, where aphids were few, without spraying. Four sprays with DDT emulsion at 2 lb. of active ingredient per acre per application, at intervals of 14 days, starting soon after the plants emerged, were enough to check spread from sources within the crop.

Insecticides did no prevent viruliferous aphids, coming from outside the crop, from infecting sprayed plants. Although many growers could safely keep potato stocks for several years longer than they do now, others could not because virus Y is introduced by aphids from other crops in the same area. Risk from incoming infective aphids will remain until all potato crops are free from virus, but if all infected crops were sprayed with an efficient aphicide before the summer dispersal flight this should greatly decrease the amount of disease introduced into healthy crops.

ZUSAMMENFASSUNG

FELDVERSUCHE IM HINBLICK AUF DIE ERHALTUNG VON KARTOFFELBESTÄNDEN IN ENGLAND

Feldversuche, die zur Ergänzung wiederholter Kleinparzellenversuche durchgeführt wurden, ergaben, daß die Häufigkeit des Auftretens der Blattroll- und Y-Viren bei Kartoffelbeständen mehrere Jahre in vielen Teilen Englands gering blieb, wenn die Bestände mit einem Insektenmittel gespritzt wurden; in manchen Teilen, in denen wenig Blattläuse vorkamen, war dies auch ohne Spritzen der Fall. Viermaliges Spritzen mit DDT-Emulsion zu 2 lb. aktiven Bestandteile pro "acre" pro Applikation in 14tägigen Intervallen, wobei man bald nach dem Aufgang begann, reichten aus, um die Ausbreitung von Quellen innerhalb der Bestände zu hemmen.

Die Insektizide verhinderten nicht, daß virustragende Blattläuse, die von außerhalb der Bestände stammten, die gespritzten Pflanzen infizierten. Obwohl manche Züchter ihre Kartoffelbestände verschiedene Jahre länger halten könnten als sie es jetzt tun, würde anderen dies nicht gelingen, weil das Y-Virus von Blattläusen aus anderen Beständen des gleichen Gebietes eingeführt wird. Die Gefahr ansteckender Blattläuse wird bestehen bleiben, bis alle Kartoffelbestände virusfrei sind; wenn jedoch alle infizierten Bestände mit einem wirksamen Blattlausmittel vor dem sommerlichen Befallsflug gespritzt würden, wäre der Umfang der Infizierung mit dieser Krankheit von gesunden Pflanzungen bedeutend zu verringern.

RÉSUMÉ

ESSAIS EN PLEIN CHAMP SUR LA CONTINUATION DE PLANTATIONS DE POMMES DE TERRE EN ANGLETERRE

Des essais en plein champ, effectués pour compléter des essais à différentes reprises sur petites parcelles, ont démontré que l'incidence des virus Y et de l'enroulement dans les cultures de pommes de terre restait faible pendant plusieurs années dans bien des régions d'Angleterre, pourvu que les cultures aient été traitées par pulvérisation d'un insecticide, et dans certaines régions, où les pucerons sont rares, mêmes sans pulvérisations. Quatre pulvérisations d'une émulsion de DDT à la dose de 2 lb. de substance active par "acre" et par pulvérisation, espacées de deux semaines, dont la première est effectuée peu après la levée, suffisaient pour enrayer la propagation à partir de sources situées à l'intérieur de la culture.

Les insecticides n'empêchaient pas les pucerons porteurs de virus, venant d'en dehors de la culture, d'infecter les plantes traitées. Si bien des cultivateurs pourraient continuer sans inconvénient la culture de pommes de terre de la même semence pendant plusieurs années de plus que d'ordinaire, d'autres ne le pourraient pas parce que le virus Y est apporté d'autres cultures de la même région par les pucerons. Le risque de

pénétration de pucerons infectieux continuera d'exister tant que toutes les cultures ne seront pas exemptes de virus. Mais si toutes les cultures infectées étaient traitées avec un insecticide efficace avant le vol de dispersion en été, il en résulterait une forte diminution de la maladie introduite dans des plantations saines.

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LETTERS TO THE EDITOR

THE SUGAR ACCUMULATION IN POTATOES KEPT AT A LOW TEMPERATURE, AS STUDIED IN A SMALL SELECTION OF SAMPLES OF DUTCH VARIETIES

Introduction

The extent to which ware potatoes sweeten when kept for a certain time at a low temperature is important both for the purpose of immediate consumption and for further working up into fried products. In the first instance sugar accumulation may give rise to an unpleasant sweet taste for the consumer, as has been known since the first researches (MÜLLER, 1882). As regards the second case, an excessive content of reducing sugars may result in an undesirable brown coloration during frying, in which connection it seems that a slight effect of the non-reducing fraction may also be distinguished (SHALLENBERGER and ORA SMITH, 1959). This sugar accumulation is also important for the industrial processing to potato flour as it is accompanied by starch loss. It will not always be possible to avoid low temperatures during storage or transport with the resultant sweetening. In the case of storage this is because a choice often has to be made between a comparatively low temperature and disastrous sprouting, and in the case of transport because the variable climate is a drawback in this country. Hence sweetening of potatoes will often be a necessary evil, although one which can be controlled by means of a brief storage (desweetening) at a comparatively high temperature (VAN VLIET and SCHRIEMER, 1959b). Apart from this possibility it is still an interesting problem whether considerable differences occur in the degree of sweetening at a low temperature in our potato varieties. In this case and if these differences were reproducible from one year to another, this might result in a preference for particular varieties for a specific purpose.

In order to obtain information on the degree of sweetening at low temperature as a possible variety character in potatoes, 20 Dutch potato varieties were compared in a simple storage experiment in the autumn of 1958. The variety samples in question all came from the same variety testfield near Wageningen and were supplied to us by the "Institute for Research on Varieties of Field Crops" there. We would like to express our gratitude to ir H. Zingstra of this Institute for his cooperation.

In these samples we investigated the increase in the contents of reducing and non-reducing sugars during a standard storage period of two months at 2°C. From the 20 variety samples thus studied, 12 were selected which showed substantial differences from each other as regards sugar accumulation. Of these 12 varieties samples were again obtained in 1959 from an experimental field belonging to the Institute for Research on Varieties of Field Crops and with these samples the storage experiment was repeated in the autumn of 1959. The results of the two experiments are compared below and we are looking for the extent to which the differences in sugar accumulation found in 1958 were again exhibited in 1959.

Methods of investigation

In both years the samples of Dutch potato varieties provided by the Institute for Research on Varieties of Field Crops were derived from the same variety test field situated at "De Born" near Wageningen. Since there were few or no indications enabling us to solve our problem the 20 variety samples studied in 1958 were chosen at random. Care was taken to ensure that varieties suitable for consumption and processing were included in this selection.

The variety selection in 1959 was based on the results of the storage experiment in 1958, 12 varieties being chosen which differed as greatly as possible as regards sugar accumulation. A sample of about 5 kg was available of each variety and was divided into two samples of about 2,5 kg each. For some weeks after lifting the samples were kept at a temperature of 5° to 10 °C before the standard storage period started. Of each variety one 2,5 kg sample was kept at 2 °C on 17th september 1958 and 5th october 1959, while the other 2,5 kg sample was examined in the laboratory. After 8 weeks, *viz.* on 13th november 1958 and 1st december 1959, the samples kept at 2 °C were also transferred to the laboratory for examination. The sample investigation comprised the determination of the dry matter content, the content of reducing sugars and the content of non-reducing sugars.

The loss of weight during storage was also determined.

For the methods of determination reference may be made to the relevant publication of our Institute (VAN VLIET and SCHRIEMER, 1958). Use is made of the paper chromatographic separation of the sugars in the alcoholic extracts of the samples. The solvent employed was normal propyl alcohol-benzyl alcohol-formic acid (98%)-water in the ratio by volume of 50:72:17,3:20 (SERMANNI, 1956); the paper used was Whatman nr 2. The inversion of the non-reducing saccharose preceding the actual chemical determination was carried out with an invertase preparate (SHALLENBERGER and MOORES, 1957). The reducing sugars were chemically determined in accordance with Nelson's colorimetric variant of the determination of SOMOGYI et al. (NELSON, 1944).

Results

TABLES 1 and 2 show the results for 1958 and 1959 respectively. For 1958 table I only includes the 12 samples with which the experiment was repeated in 1959.

The chromatographic part of the investigation showed that the reducing sugar fraction consists of glucose and fructose, whereas the non-reducing fractions consists only of saccharose. The sugar contents are expressed as a percentage by weight of the undried sample material. The loss of weight during storage is expressed as a percentage of the initial weight.

Discussion

The fact that in this and other investigations (VAN VLIET and SCHRIEMER, 1959a) glucose, fructose and saccharose were the only sugars found in the potato tuber is in agreement with data supplied by the literature on the subject, for instance as determined in WEGNER's survey (WEGNER, 1956). In the examination of the samples at our disposal we were unable to confirm that maltose is formed in the cold (HABIB and BROWN, 1957). A comparison between the sugar contents before storage in both years shows that they were considerably higher in 1959 than in 1958. This possibly fits in the general pattern exhibited by potatoes in the very warm and dry year 1959.

TABLE 1. Sugar accumulation in 12 Dutch potato varieties during storage at 2°C from 17-9-1958 to 13-11-1958

Variety – *Sorte – variété*	Before storage – *vor der Einlagerung – avant le stockage*		After storage – *nach der Einlagerung – après stockage*		Loss of weight *Gewichtsverl. Perte de poids*
	red. % [1]	sacch. % [2]	red. % [1]	sacch. % [2]	%
Alpha	0,19	0,01	1,86	0,60	3,9
Climax	0,12	0,23	2,45	0,36	3,6
Froma	0,10	0,04	1,46	0,46	5,4
Gineke	0,10	0,11	1,60	0,68	4,6
Industrie	0,46	0,15	1,68	0,69	4,7
Libertas	0,06	0,14	1,35	1,26	4,5
Maritta	0,18	0,17	0,63	0,95	7,8
Noordeling	0,11	–	0,65	0,88	5,5
Prudal	0,14	0,06	1,33	1,01	4,3
Record	0,14	0,19	1,73	0,98	8,6
Rode Star	0,08	0,15	0,79	1,16	7,4
Voran	0,36	0,20	1,49	0,69	5,3

[1] Percentage of reducing sugars (glucose + fructose) – *Prozentsatz von reduzierenden Zuckern (Glukose + Fruktose) – pourcentage de sucres réducteurs (glucose + fructose).*

[2] Percentage of non-reducing saccharose – *Prozentsatz der nicht reduzierenden Saccharose – pourcentage de saccharose non réducteur.*

TABELLE 1. *Zuckeranhäufung in 12 holländischen Kartoffelsorten während Einlagerung bei 2°C vom 17.9. 1958 bis 13.11.1958*

TABLEAU 1. *Accumulation de sucres dans 12 variétés hollandaises de pomme de terre pendant la conservation à 2°C du 17-9-1958 au 13-11-1958*

TABLE 2. Sugar accumulation in 12 Dutch potato varieties during storage at 2 °C from 5-10-1959 to 1-12-1959

Variety – *Sorte – variété*	Before storage – *vor der Einlagerung – avant le stockage*		After storage – *nach der Einlagerung – après stockage*		Loss of weight *Gewichtsverl. Perte de poids* %
	red. % [1]	sacch. % [2]	red. % [1]	sacch. % [2]	
Alpha	1,17	0,30	2,65	0,43	1,8
Climax	0,95	0,40	2,55	0,52	3,4
Froma	0,31	0,53	2,09	0,81	2,6
Gineke	0,65	0,47	1,95	0,83	2,2
Industrie	0,86	0,57	1,64	0,65	2,6
Libertas	0,65	0,96	2,17	1,49	2,5
Maritta	0,44	0,80	0,59	1,47	2,7
Noordeling	0,38	0,61	1,13	0,84	2,1
Prudal	0,99	0,54	1,67	0,59	1,8
Record	0,65	0,48	2,00	0,76	1,9
Rode Star	0,33	0,65	0,86	0,72	2,3
Voran	0,56	0,45	1,52	0,46	2,8

[1], [2] See notes in TABLE 1 – *siehe Anmerkungen zu* TABELLE 1 – *voir notes du* TABLEAU 1.

TABELLE 2. *Zuckeranhäufung in 12 holländischen Kartoffelsorten während Einlagerung bei 2 °C vom 5.10. 1959 bis 1.12.1959*

TABLEAU 2. *Accumulation de sucres dans 12 variétés hollandaises de pommes de terre pendant la conservation à 2 °C du 5-10-1959 au 1-12-1959*

When we come to compare the results of the experiments in 1958 and 1959 we first do this by juxtaposing the ratios of the sugar contents after the 8 weeks of storage for both years. This is in analogy with the fact that farmers will also be mainly interested in the sugar contents after an undesirable but possibly unavoidable period of cold storage. As regards the reducing sugars, a comparison of the two years is made in FIG. 1 in which the varieties examined are delineated in a scale division which indicates the percentage of reducing sugars after storage. The result of this comparison is that in both years the same three groups of varieties may be distinguished, *viz.*:

Group 1: *Alpha* and *Climax* which are characterised by comparatively high reducing sugar contents;

Group 2: *Record, Industrie, Gineke, Voran, Froma, Libertas* and *Prudal* which occupy an intermediate position as regards content of reducing sugars;

Group 3: *Rode Star, Noordeling* and *Maritta* which are characterised by comparatively low reducing sugar contents.

In this connection it should be noted that within these groups further considerable differences occur in order along the two scales. When a figure of this kind is constructed for the saccharose contents it is found impossible to discover a reasonable agreement between the results of both years.

When the sugar contents are based on the dry weight instead of on the fresh undried sample weight the relative pattern is hardly if at all altered.

In addition to the content after storage, which is the most practical and direct index of sweetening, it is desirable to take into consideration a magnitude denoting the increase in the amount of sugar in the tuber. The magnitude chosen was the number of grams of reducing sugar or saccharose produced and stored by 1 kg (initial weight) of tubers during storage at 2 °C. This value, designated by Z, follows from:

$$Z = (10 - 0{,}1\,v)\,S_n - 10\,S_v$$

wherein S_v = content before storage, S_n = content after storage (in % of the fresh, undried material) and v = loss of weight during storage (in % of the initial weight).

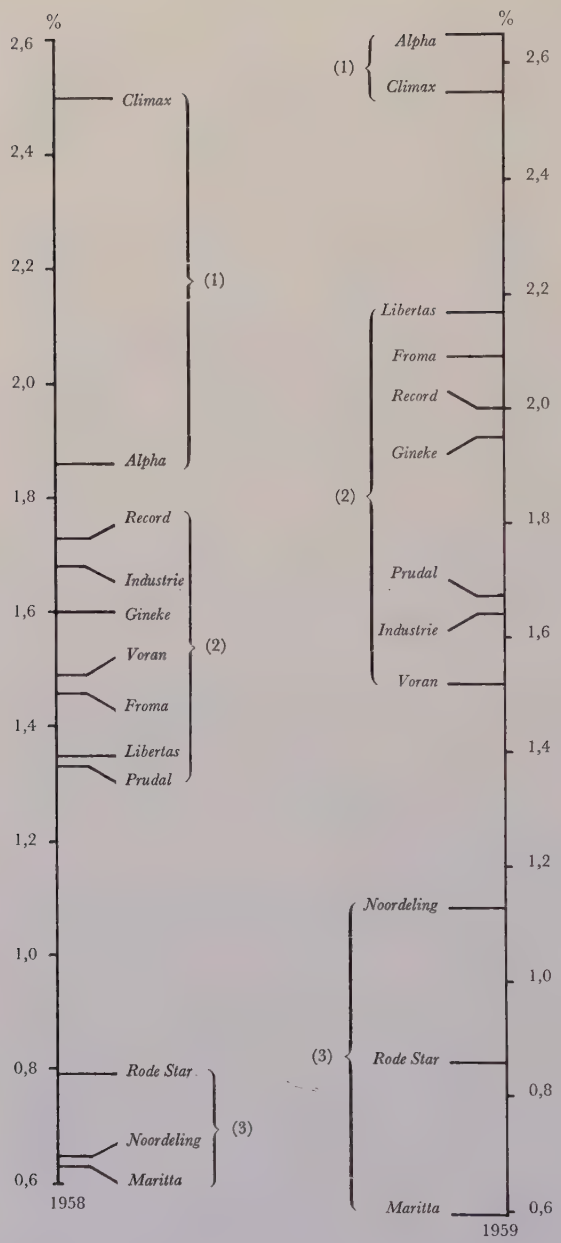

FIG. 1. The reducing sugars content of 12 Dutch potato varieties after storage at 2 °C during 8 weeks in 1958 and 1959

ABB. 1. *Der Gehalt an reduzierenden Zuckern von 12 holländischen Kartoffelsorten nach 8-wochiger Einlagerung bei 2 °C in 1958 und 1959*

FIG. 1. *La teneur en sucres réducteurs de 12 variétés hollandaises de pommes de terre après conservation à 2 °C pendant 8 semaines en 1958 et 1959*

TABLE 3. The Z values corresponding to the sugar accumulations shown in TABLES 1 and 2.

Variety – *Sorte – variété*	1958		1959	
	red.[1]	sacch.[2]	red.[1]	sacch.[2]
Alpha	16,0	5,8	14,3	1,2
Climax	22,4	1,2	15,2	1,0
Froma	12,8	4,0	17,4	2,6
Gineke	14,3	5,4	12,6	3,4
Industrie	11,4	5,1	7,4	0,6
Libertas	12,3	10,6	14,7	4,9
Maritta	4,0	7,1	1,4	6,3
Noordeling	5,1	8,3	7,3	2,1
Prudal	11,2	9,1	6,5	0,4
Record	14,3	7,1	13,1	2,7
Rode Star	6,6	9,2	5,1	0,5
Voran	10,6	4,5	9,2	–

[1] Reducing sugars (glucose + fructose) – *reduzierende Zucker (Glukose + Fruktose) – Sucres réducteurs (glucose + fructose).*
[2] Non-reducing saccharose – *nicht reduzierende Saccharose – saccharose non réducteur.*

TABELLE 3. *Die mit den Zuckeranhäufungen der* TABELLEN 1 *und* 2 *übereinstimmenden Z-Werte*
TABLEAU 3. *Les valeurs Z correspondant aux accumulations des sucres indiquées dans les* TABLEAUX *1 et 2*

TABLE 3 shows the Z values for reducing sugars and non-reducing saccharose for both years.

In the same way as in the case of the sugar contents, in FIG. 2 the 12 varieties examined are delineated on a Z scale for the reducing sugars. Of these 12 varieties, starting from Climax there are 8 in the same order along the two scales. These are *Climax*, *Alpha*, *Record*, *Gineke*, *Industrie*, *Prudal*, *Rode Star* and *Maritta*. The remaining four varieties, *viz. Froma*, *Libertas*, *Voran* and *Noordeling*, also have the same order among themselves along the scales, but compared to the remaining varieties this group is situated at higher Z values in 1959 than 1958.

A figure of this kind constructed for the Z values of the saccharose accumulation shows no points of agreement between the years 1958 and 1959.

With the exception of *Froma*, *Libertas* and *Prudal* the group division shown in FIG. 1 is repeated in FIG. 2. If we are asked in what way the variety differences found in 1958 with regard to sweetening at 2 °C for eight weeks were repeated in 1959, our answer must be, that with respect to the accumulation of reducing sugars there is certainly an indication that the variety differences are reproducible. This is both true when the content is noted after cold storage as when the result is based on the amount formed and stored during storage. But such indication could not be obtained with respect to the non-reducing saccharose. It might therefore be supposed that the variety differences will be especially reflected in the frying of chips and similar products in which processes the reducing sugars are so important with regard to the colour. Such varieties as *Noordeling*, *Rode Star*, and *Maritta* would in this case be extra favourable, where as varieties such as *Alpha* and *Climax* appear less attractive. The same would also be true of the table quality of boiled potatoes in connection with a possible sweet taste. It should be remembered, however, that the foregoing observations only deal with the reducing part of the total sugar content and that further research is required as regards the relationship between variety and saccharose accumulation.

Since we are guided by the points of agreement between the results for 12 samples in 1958 and 1959 we have greater confidence in showing the results of the original selection of 20 samples examined in 1958. Hence FIG. 3 summarises the reducing sugar contents after storage at 2 °C of all samples investigated in that year. Proceeding along the scale from the bottom to the top we find approximately the order in which the swee-

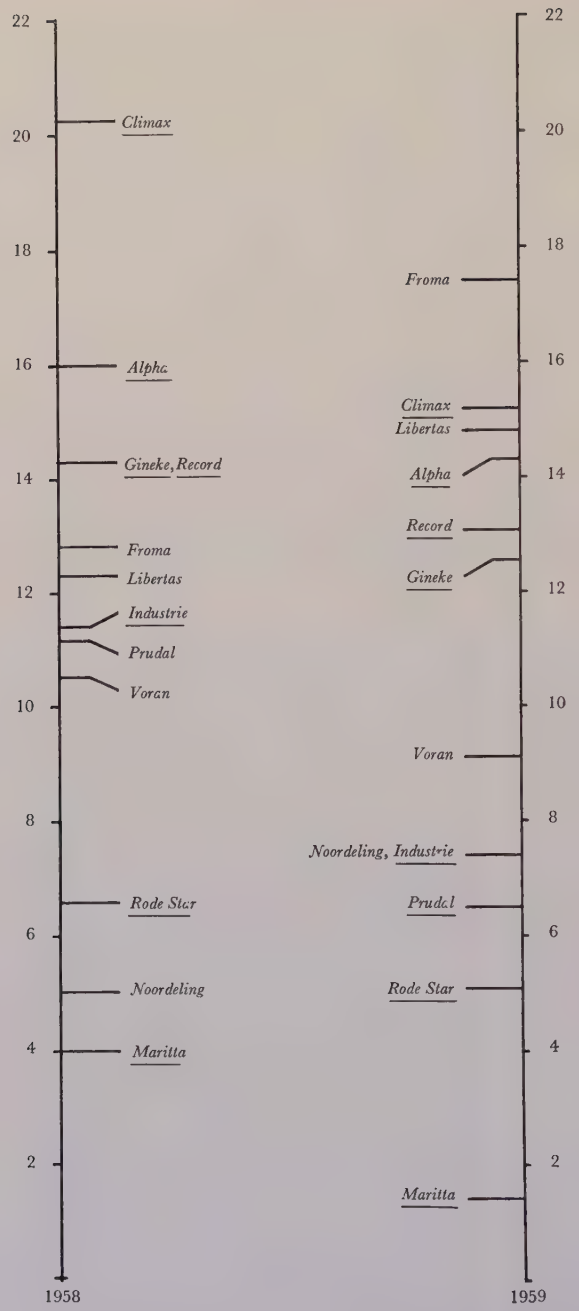

FIG. 2. The reducing sugars accumulation, indicated by the Z-value, of 12 Dutch potato varieties during storage for 8 weeks in 1958 and 1959

ABB. 2. *Die vom Z-Wert angedeutete Anhäufung von reduzierenden Zuckern von 12 holländischen Kartoffelsorten während 8-wochiger Einlagerung in 1958 und 1959*

FIG. 2. *Accumulation de sucres réducteurs, indiquée par la valeur Z, durant la conservation pendant 8 semaines de 12 variétés hollandaises de pommes de terre en 1958 et 1959*

Z denotes grams reducing sugars accumulated in 1 kg (initial weight) – *Z bedeutet reduzierende Zucker akkumuliert in 1 kg (Ausgangsgewicht) in Grammen – Z signifie nombre de grammes de sucres réducteurs accumulés en 1 kg (poids initial)*

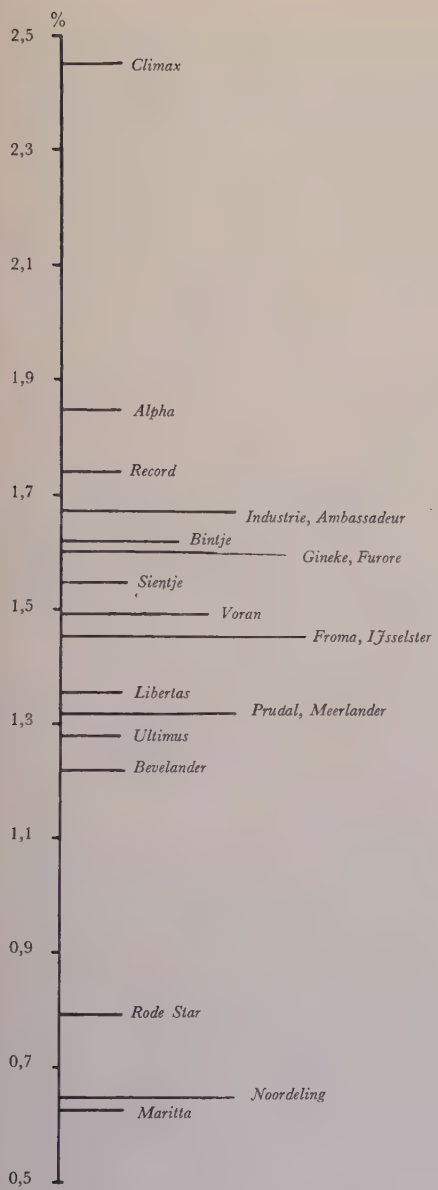

FIG. 3. The reducing sugars content of 20 Dutch potato varieties after storage at 2 °C during 8 weeks in the autumn of 1958

ABB. 3. *Der Gehalt an reduzierenden Zuckern von 20 holländischen Kartoffelsorten nach 8-wochiger Einlagerung bei 2 °C im Herbst 1958*

FIG. 3. *La teneur en sucres réducteurs de 20 variétés hollandaises de pommes de terre après conservation à 2 °C pendant 8 semaines en automne de 1958*

tening of the varieties included increases at low temperature.
Bevelander and *Ultimus* may possibly be mentioned in addition to the only slightly sweetening varieties *Rode Star*, *Noordeling* and *Maritta* already referred to. *Climax*, and to a lesser extent *Alpha* and *Record*, appear to be very susceptible to sweetening. The remaining varieties occupy an intermediate position along the scale division.

SUMMARY

In 1958 a relatively random selection of 20 samples of Dutch potato varieties from the same variety test field of the Institute for Research on Varieties of Field Crops, Wageningen, was examined for sweetening during a storage period of two months at 2 °C. In 1959 the investigation was repeated with 12 of these varieties which showed considerable differences from each other as regards sugar accumulation. A comparison of the results in both years showed that there is a good indication that the differences with respect to the accumulation of reducing sugars are reproducible from one year to another. In both years *Rode Star*, *Noordeling* and *Maritta* accumulated very little reducing sugar, where as *Climax* and *Alpha* accumulated it to a very marked extent. No evidence was found for such a reproduction of differences with respect to the accumulation of non-reducing sugars.
Chromatographic investigation showed that the reducing sugar fraction consists of glucose and fructose, where as the non-reducing fraction only contains saccharose.

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ZUSAMMENFASSUNG

DIE ZUCKERAKKUMULATION IN KARTOFFELN BEI NIEDRIGER TEMPERATUR, UNTERSUCHT IN EINEM KLEINEN ASSORTIMENT VON NIEDERLÄNDISCHEN SORTENPROBEN

Im Jahre 1958 wurde ein verhältnismässig willkürliches Assortiment von 20 niederländischen Kartoffelsortenproben – bezogen von demselben Versuchsfelde des Instituts für Sortenprüfung Landwirtschaftlicher Kulturpflanzen, Wageningen – untersucht mit dem Zweck das Süsswerden während einer Lagerung von 2 Monaten bei 2 °C nachzuprüfen. Die Untersuchung wurde im Jahre 1959 mit 12 von diesen Sorten wiederholt, welche gegenseitig bedeutende Unterschiede hinsichtlich der Zuckeranhäufung zeigten. Der Vergleich der Ergebnisse von beiden Jahren führte zum Schluss, dass die gegenseitige Unterschiede hinsichtlich der Akkumulation von reduzierenden Zuckern sich wahrscheinlich wiederholen.
In beiden Jahren war die Anhäufung von reduzierenden Zuckern bei *Rode Star*, *Noordeling* und *Maritta* nicht sehr bedeutend, während *Climax* und *Alpha* eine hohe Akkumulation zeigten.
Hinsichtlich der Akkumulation von nicht-reduzierenden Zuckern wurde eine derartige Wiederholung von wechselseitigen Differenzen nicht gefunden. Aus chromatographischen Untersuchungen ging hervor dass Glukose und Fruktose den reduzierenden Teil bilden, während Saccharose der einzige nicht-reduzierende Zucker ist.

RÉSUMÉ

ACCUMULATION DE SUCRES DANS LES POMMES DE TERRE A BASSE TEMPÉRATURE, ÉTUDIÉE DANS UNE PETITE COLLECTION D'ÉCHANTILLONS DE VARIÉTÉS HOLLANDAISES

En 1958, une collection d'échantillons assez arbitrairement composée de 20 variétés hollandaises de pommes de terre – reçue d'un seul champ d'essais de l'Institut des Recherches sur

les Variétés de Plantes de Grande Culture à Wageningen – a été étudiée dans le but d'observer l'augmentation de la teneur en sucre durant 2 mois de conservation à 2 °C. L'étude a été répétée en 1959 pour 12 de ces variétés, entre lesquelles existaient de fortes différences quant à l'accumulation de sucres. La comparaison des résultats des deux années a amené à conclure que les différences entre les variétés en ce qui concerne l'accumilation de sucres réducteurs se reproduisent probablement d'une année à l'autre.

Dans l'une et l'autre année, l'accumulation de sucres réducteurs dans les *Rode Star*, *Noorderling* et *Maritta* était peu importante, tandis que les *Climax* et les *Alpha* présentaient une forte accumulation.

Pour ce qui est de l'accumulation de sucres non réducteurs, il n'a pas été constaté de telle répétition des différences entre les variétés. Les essais chromatographiques ont permis de constater que le glucose et le fructose constituent la part réductrice, tandis que le saccharose est le seul sucre non réducteur.

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ABSTRACTS

P. N. HARVEY & J. L. SHORT: Effect of date of planting on yield of main crop potatoes. *Exp. Husbandry*. **4** (1959) 7–17.

An article published by Dyke[1] some years ago summarized the results of a number of experiments on the effect of date of planting on yield of potatoes and also the information gained from a nation-wide survey. He concluded that yield was not much affected by date of planting up to the first week in April, but after that time each week's delay in planting reduced the yield by 0,3–0,6 tons of tubers per acre. Other results are mainly applicable to the stronger and more fertile land in use for potato growing. The results of experiments on lighter soils conducted at the Norfolk Agricultural Station from 1948–1953 were available to DYKE only in a brief form. In the present article of HARVEY and SHORT the results are discussed in greater detail.

From 1948–1953 *Majestic* and *Arran Banner* (*Majestic* and *King Edward* in 1953) were planted on three dates with an interval of about three weeks. In 1948, 1949 and 1950 the planting at distances of 12, 16 and 20 in. was tried out at the same time.

On the average of 4 year's trials the total yield of potatoes planted in the first week of May was about 1 ton/acre lower than the crop planted in the second week of April or the third week of March, there being no difference between the March and April plantings. In the case of the ware potato sizes (> 2 in.) the reduction was perhaps somewhat greater.

It was only in 1948 that the two varieties did not respond in the same way to different times of planting. At the early planting *Majestic* yielded 1,5 ton/acre more, but at the late planting gave 1 ton/acre less than *Arran Banner*.

There was little difference between the two varieties in their response to setting distance. Planting at 20 in. intervals caused a slight reduction in total yield, but increased the yield of ware by 1 ton/acre in comparison with 12 in.

Under the dry conditions in 1949 both varieties gave a significantly higher yield from short spacing and early planting and from wide spacing and late planting. The yields of ware were even the same for these combinations of planting time and setting distance. In 1950 there was a similar trend.

In 1953 the response to fertilizer quantities was not affected by the time of planting.

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[1] G. V. DYKE: The effect of date of planting on the yield of potatoes. *J. Ag. Sci.* **47** (1956) 122.

DER EINFLUSS DES PFLANZDATUMS AUF DEN ERTRAG AN KARTOFFELN BEI SPÄTKARTOFFELERZEUGUNG

In einer vor einigen Jahren erschienenen Veröffentlichung von DYKE[1] sind die Ergebnisse einer Anzahl Versuche über den Einfluss des Pflanzdatums und einer ländlichen Untersuchung zusammengefasst. Der Schluss war, dass der Ertrag bis in die erste Aprilwoche hinein wenig durch das Pflanzdatum beeinflusst wird, danach jedoch verursachte jede Woche Verzögerung im Pflanzen eine Ertragsverminderung von 750–1500 kg/ha. Andere Resultate bezogen sich hauptsächlich auf die für den Kartoffelbau besseren Böden, und da die Versuchsergebnisse der Norfolk Agricultural Station von 1948–1953 auf leichteren Böden damals nur sehr beschränkt zur Verfügung standen, werden diese in dem vorliegenden Artikel von HARVEY u. SHORT ausführlicher besprochen.

In den Jahren 1948–1953 wurden 2 Sorten, *Majestic* und *Arran Banner* (1953 *Majestic* und *King Eduard*) an 3 verschiedenen Daten mit durchschnittlich ± 3 Wochen Zwischenzeit ausgepflanzt. 1948, 1949 und 1950 wurden zugleich die Pflanzenabstände in den Reihen von 30, 40 und 50 cm geprüft.

Im Durchschnitt über 4 Vergleichsjahre zeigte sich kein Unterschied zwischen den ersten zwei

[1] G. V. DYKE: The effect of date of planting on the yield of potatoes. *J. Agric. Sci.* **47** (1956) 122.

Pflanzdaten (der 3. Märzwoche und der 2. Aprilwoche), aber ein Pflanztermin in der 1. Maiwoche hatte eine Gesamtertragsverminderung von $\pm 2{,}5$ t/ha zur Folge, für das Verbrauchsmass (> 50 mm) war die Verminderung sogar noch etwas grösser.
Nur 1948 reagierten die Sorten nicht in gleicher Weise auf das Pflanzdatum. *Majestic* erbrachte bei frühem Pflanzen 3,75 t/ha mehr, bei spätem Pflanzen 2,5 t/ha weniger als *Arran Banner*.
Auf den Pflanzenabstand reagierten beide Sorten ziemlich gleich. 50 cm ergab durchschnittlich einen etwas niedrigeren Gesamtertrag. Verglichen mit 30 cm brachten 50 cm Abstand jedoch 2,5 t/ha mehr an Verbrauchsmass (> 50 mm) auf.
Beide Sorten hatten in der trockenen Saison von 1949 bei frühem Pflanzen mit kleinem Abstand und bei spätem Pflanzen mit grossem Abstand die höchsten Gesamterträge, selbst gleiche Erträge an Verbrauchsmass. Auch 1950 bestand eine solche Tendenz.
Ein 1953 durchgeführter Düngungsversuch ergab keinen Unterschied in der Reaktion auf die Düngungsstufen bei verschiedenen Pflanzdaten.

INFLUENCE DE L'ÉPOQUE DE PLANTATION SUR LE RENDEMENT DES POMMES DE TERRE TARDIVES

Un article publié par DYKE[1] il y a quelques années résumait les résultats d'un certain nombre d'essais concernant l'influence de l'époque de plantation sur le rendement des cultures de pommes de terre ainsi que les renseignements provenant d'une recherche dans le pays entier. Sa conclusion était qu'avant la première semaine d'avril, l'époque de plantation influence peu le rendement, mais qu'après cela, chaque semaine de retard apporté à la plantation réduit la récolte de 750–1500 kg/ha. D'autres résultats ne s'appliquaient qu'aux terres plus grasses et plus fertiles utilisées pour la culture de la pomme de terre. Les résultats d'essais effectués dans des sols plus légers par la Station Agricole de Norfolk dans les années 1948–1953 n'étaient disponibles à DYKE que sous forme limitée. Le présent article de HARVEY et SHORT en donne une discussion plus détaillée.
De 1948 à 1953, les variétés *Majestic* et *Arran Banner* (*Majestic* et *King Edward* en 1953) furent plantées à trois dates espacées de trois semaines environ. En 1948, en 1949 et en 1950, la plantation par intervalles de 30, 40 et 50 cm fut soumis à un examen en même temps.
En moyenne pour les quatre années d'essais, la récolte totale des pommes de terre plantées dans la première semaine de mai fut inférieure d'environ 2,5 tonne/ha à celle de la culture plantée dans la deuxième semaine d'avril ou la troisième semaine de mars, les cultures plantées en mars et en avril ne présentant pas de différences. En ce qui concerne les pommes de terre de grosseur les destinant à la consommation (> 50 mm), la réduction était peut-être un peu plus importante. Ce n'est qu'en 1948 que les deux variétés ne répondirent pas de la même manière aux différentes dates de plantation. Après plantation précoce, *Majestic* produisit 3,75 tonne/ha de plus, mais après plantation tardive, cette variété eut un rendement inférieur de 2,5 tonne/ha à celui d'*Arran Banner*.
En ce qui concerne l'influence de l'espacement des plants, les deux variétés différaient peu. L'espacement de 50 cm causa une légère réduction de la récolte totale mais augmenta la production de pommes de terre potagères de 2,5 tonne/ha par rapport à l'espacement de 30 cm.
Sous la sécheresse de 1949, l'une et l'autre variété présentèrent une nette supériorité de rendement en cas de plantation serrée effectuée tôt et en cas de plantation fort espacée et tardive. Les récoltes de pommes de terre potagères furent même égales pour ces deux associations d'époque de plantation et d'espacement des plants. La même tendance se manifesta en 1950.
En 1953, l'effet des quantités d'engrais ne fut pas modifié par l'époque de plantation.

[1] G. V. DYKE: The effect of date of planting on the yield of potatoes. *J. Agr. Sci.* **47** (1956) 122.

REVIEWS

1. AMERICAN POTATO YEARBOOK 1960, EDITORIAL OFFICE, POST OFFICE BOX 540, WESTFIELD, NEW JERSEY, U.S.A.

The 1960 edition of the *American Potato Yearbook* has come off the press. The current volume contains 80 pages.

A special feature is the illustrated article on "Potato Diseases and Their Control" by JOHN C. CAMPBELL, Potato Specialist at the New Jersey Agricultural Experimental Station. Also of great interest are two pages of complete figures on potato acreage, yield, production, farm disposition and utilization in the U.S.A. from 1919 to 1958. There is, in addition, a current list of recent references to potato culture in the U.S.A. and Canada, comprehensive information on United States Standards for Potatoes and complete details on leading potato-producing areas.

Other interesting items include rules and regulations affecting the shipment of seed potatoes, 1960 acreage guides, a list of leading United States and Canadian associations engaged in the improvement of potatoes, together with the names of United States and Canadian seed certification officials.

The new volume again contains a wealth of statistical information. There are tabulations of both seed and table stock production as well as statistics on Canadian and world production. The 1960 Onion Supplement has been completely revised. It includes recently published literature on onions, a feature article on the National Onion Association etc.

Copies of the Yearbook may be secured from the *American Potato Yearbook*, Post Office Box 540, Westfield, New Jersey. An individual copy sells for $ 2.00. A complete volume, 1950–1960 is available at $ 14.00.

AMERIKANISCHES KARTOFFELJAHRBUCH FÜR 1960

Die Ausgabe für 1960 des *American Potato Yearbook* ist soeben erschienen. Der heutige Band enthält 80 Seiten.

Besonders erwähnenswert ist der illustrierte Artikel über "Potato Diseases and their Control" von JOHN C. CAMPBELL, Kartoffelspezialist an der Landwirtschaftlichen Versuchsstation von New Jersey. Sehr interessant sind auch zwei Seiten mit erschöpfendem Zahlenmaterial über Anbaufläche, Erträge, Produktion, Einrichtung und Arbeitsweise der Bauernwirtschaften in den Vereinigten Staaten von 1919 bis 1958. Ferner enthält das Buch die neuesten Literaturangaben über den Kartoffelbau in den Vereinigten Staaten und Kanada, ausführliche Einzelheiten über die amerikanischen Normenvorschriften für Kartoffeln und erschöpfende Auskunft über die wichtigsten Kartoffelanbaugebiete.

Von Interesse sind ferner die Vorschriften und Bestimmungen für die Beförderung von Saatkartoffeln, ein Führer für die Anbauflächen für 1960, ein Verzeichnis der führenden amerikanischen und kanadischen Verbände, die sich mit der Verbesserung der Kartoffel befassen, sowie ein Namenverzeichnis der amtlichen Begutachter von Saatgut in den Vereinigten Staaten und Kanada.

Der neue Band zeichnet sich wieder durch eine Überfülle an statistischem Material aus. Er enthält Tabellen über die Erzeugung von Saat- und Speisekartoffeln und Statistiken über die kanadische und Weltproduktion. Der Nachtrag für 1960 über die Zwiebelzucht ist vollständig neubearbeitet. Er enthält neue Veröffentlichungen über Zwiebeln, einen wichtigen Artikel über die National Onion Association etc.

Exemplare des Jahrbuches können erhalten werden bei: *American Potato Yearbook*, Post Office Box 540, Westfield, New Jersey. Ein einzelnes Exemplar kostet $ 2,00. Ein vollständiger Band 1950–1960 ist für $ 14,00 erhältlich.

ANNALES AMÉRICAINES DE LA POMME DE TERRE 1960

L'édition 1960 de l'*American Potato Yearbook* vient de paraître. Cette édition comprend 80 pages.

Un intérêt spécial est présenté par l'article illustré, intitulé "Potato Diseases and their Control", de la main de JOHN C. CAMPBELL, expert de la culture des pommes de terre de la New Jersey Agricultural Experimental Station. Une autre partie intéressante est représentée par deux pages de chiffres complets sur la superficie de pommes de terre, la récolte, la production, la disposition et l'utilisation des fermes aux Etats-Unis de 1919 à 1958. Il y a en outre une liste récente de références bibliographiques sur la culture de la pomme de terre aux Etats-Unis et au Canada, des renseignements détaillés sur les normes américaines concernant la pomme de terre et des données complètes sur les principales régions productrices de pommes de terre.

Autres sujets intéressants: règlements et prescriptions concernant l'expédition de plants de pomme de terre, indications sur les superficies cultivées en 1960, une liste des principales organisations des Etats-Unis et du Canada pour l'amélioration de la pomme de terre, ainsi que les noms des fonctionnaires délivrant les certificats sur les plants aux Etats-Unis et au Canada.

Le nouveau volume contient, comme les anciens, une riche documentation statistique. Il y a des tableaux sur la production de poinmes de terre de semence et potagères aussi bien que des statistiques sur la production canadienne et la production mondiale. L'Onion Supplement 1960 a été entièrement revu. Il contient la littérature récente sur les oignons, un article spécial sur la National Onion Association, etc.

L'annuaire est en vente chez *American Potato Yearbook*, Post Office Box 540, Westfield, New Jersey. Le volume isolé coûte 2,00 $. Un volume complet 1950–1960 est en vente au prix de 14,00 $.

2. LIST OF INTERNATIONAL POTATO RESEARCH PROJECTS WITH NAMES AND ADDRESSES OF THE RESEARCH WORKERS, COMPILED BY THE INTERNATIONAL RELATIONS COMMITTEE 1958 OF THE POTATO ASSOCIATION OF AMERICA

We should like to draw reader's attention to this list which was published in the *American Potato Journal*, December 1958, Vol. 35, No 12, 789–803 and January 1959, Vol. 36, No 1, 34–44.

According to the compilers it is by no means complete, but it will be of great value to all persons interested in potato research work being conducted in many countries.

Research workers who have not the relevant issues of the *American Potato Journal* at hand may borrow the list from the administrative centre of our Association, P.O.B. 20, Wageningen, Netherlands.

LISTE VOM INTERNATIONALEN KARTOFFELVERSUCHSWESEN MIT DEN NAMEN UND ANSCHRIFTEN DER FORSCHER, ZUSAMMENGESTELLT DURCH DAS INTERNATIONAL RELATIONS COMMITTEE 1958 DER POTATO ASSOCIATION OF AMERICA

Wir möchten gerne die Aufmerksamkeit unserer Leser auf diese Liste lenken, die im *American Potato Journal* vom Dezember 1958, Vol. 35, No. 12, S. 789–803 und vom Januar 1959, Vol. 36, No. 1, S. 34–44 veröffentlicht wurde.

Die Verfasser dieser Liste meinen dass diese keineswegs vollständig ist, jedoch für alle jene die in der Forschungsarbeit der Kartoffel in verschiedenen Ländern interessiert sind, von grossem Wert sein kann.

Forscher, denen die betreffenden Hefte des *American Potato Journal* nicht zur Verfügung stehen, können diese Liste von unserer Gesellschaft, Postfach 20, Wageningen, Holland, leihweise erhalten.

LISTE INTERNATIONALE DES PROGRAMMES DE RECHERCHES CONCERNANT LA POMME DE TERRE AVEC LES NOMS ET ADRESSES DES CHERCHEURS, COMPOSÉE PAR LE COMITÉ DE RELATIONS INTERNATIONALES 1958 DE LA POTATO ASSOCIATION OF AMERICA

Nous voulons signaler l'existence de cette liste publiée par l'*American Potato Journal*, décembre 1958, vol. 35 No. 12, 789–803, et janvier 1959, vol. 36 No 1, 34–44.

Les auteurs de cette liste déclarent qu'elle est loin d'être complète. Pourtant, la liste sera de grande valeur pour toute personne qu'intéressent les recherches relatives à la pomme de terre, en cours dans bien des pays.

Aux chercheurs qui ne disposent pas de ces numéros de l'*American Potato Journal*, la liste sera envoyée sur demande en communication par le centre administratif de notre Association, Boîte Postale 20, Wageningen, Pays-Bas.

3. A. E. Cox & E. C. Large: POTATO BLIGHT EPIDEMICS THROUGHOUT THE WORLD

Agricultural Handbook No. 174. Agricultural Research Service, United States Department of Agriculture, Washington, D.C., U.S.A., 1960 – pp. 230 with 109 tables and 94 figures in the text. Paper cover, unpriced; single copies free on application to the Agricultural Research Service, United States Department of Agriculture, Washington.

This important study was made possible by the Wisconsin Alumni Research Foundation, U.S.A., which administered funds for the purpose.

The authors, both of whom are on the staff of the Plant Pathology Laboratory, Ministry of Agriculture, Fisheries and Food, Harpenden, England, working in collaboration with about 80 specialists from many countries, have assembled data on *blight* epidemics in almost every country in the world. An important and remarkable thing is that their efforts have resulted in a most readable book.

The objects of the study were:

1. to explore as far as possible the findings in those countries where special surveys have been made;
2. to draw attention to the methods used;
3. to apply the results in principle for the interpretation of such scattered information as is available in other countries, to provide the beginnings of a mid-twentieth century conspectus for the world.

The distribution of the potato and the blight fungus, and the influence of climate on both, are discussed in the introduction. Surveys are then made of almost every country in which the potato and *Phytophthora infestans* are of importance. In general these include data on:

1. potato growing (distribution, acreage, yield, varieties);
2. climate;
3. potato blight forecasting;
4. distribution and frequency of blight epidemics
5. losses attributable to blight;
6. control measures;

The surveys are not uniform as much more is known about *Phytophthora* in some countries than in others and the length of a survey is certainly not a measure of the importance of either the potato crop or the blight fungus in that particular country. The survey relating to the reviewer's own country is of a high standard; he does not feel competent to comment on those relating to other countries.

Numerous conclusions are brought together in the last chapter. A remarkable one is that: "The general evidence shows that throughout the main potato producing countries of the world, blight years are of greater potential yield than drier years when there is less blight. In other words, drought or shortage of rain is of far greater consequence than blight in reducing potato yields, and this is true not only in Northern Europe and North America, but toughout the world as a whole".

An extensive bibliography is included. Although this book is primarily of importance to the specialist, it should prove of value to all interested in potato growing in other countries.

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KARTOFFELFÄULEEPIDEMIEN IN DER GANZEN WELT

Das Erscheinen dieses wichtigen Aufsatzes wurde durch die Wisconsin Alumni Research Foundation, U.S.A., ermöglicht, die für diesen Zweck die Mittel zur Verfügung stellte.

Beide Verfasser, die wissenschaftliche Mitarbeiter des Laboratoriums für Phytopathologie in Harpenden, England des britischen Ministeriums für Landwirtschaft, Fischerei and Lebensmittelwesen sind und mit etwa 80 Spezialisten aus vielen Ländern kollaborierten, haben Angaben über das epidemische Auftreten der Kartoffelfäule in beinahe jedem Land der Welt gesammelt. Es ist eine wichtige und beachtenswerte Sache, dass ihre Bemühungen in einem so gut lesbaren Buch zum Ausdruck gekommen sind.

Der Gegenstand ihres Aufsatzes erstreckt sich auf:

1. die Forschungsergebnisse aus Ländern, wo spezielle Untersuchungen stattgefunden haben, so gut als möglich auszubeuten;
2. die Beachtung auf die angewandten Methoden zu lenken;
3. Die Ergebnisse dieser in anderen Ländern so sehr verstreut verfügbaren Informationen prinzipiell für die Schaffung der Grundlagen einer Weltübersicht für die Mitte des 20. Jahrhunderts anzuwenden.

Die Verbreitung des Kartoffelanbaus und vom Pilz der Kartoffelfäule, sowie der Einfluss der klimatischen Verhältnisse auf beide sind in der Einleitung behandelt. Darauf folgen Übersichten aus allen Ländern, wo die Kartoffel und die *Phytophthora infestans* bedeutsam sind. Sie umfassen im allgemeinen Angaben über:

1. den Kartoffelanbau (Verbreitung, Anbaufläche, Ertrag, Sorten);
2. die klimatischen Verhältnisse;
3. die Prognose der Kartoffelfäule;
4. die Verbreitung und die Häufigkeit der Kartoffelfäuleepidemien;
5. die durch Kartoffelfäule verursachten Verluste;
6. die Bekämpfungsmassnahmen.

Die Übersichten sind nicht einheitlich, da man sich in einigen Ländern mehr mit der *Phytophthora* befasst als in anderen Ländern, so dass die Länge einer Übersicht darum keineswegs ein Maßstab für die Bedeutung der Kartoffelpflanze oder des Erregerpilzes in einem speziellen Land ist. Die von dem Land des Kommentators (die Niederlande) gegebene Übersicht ist auf einem sehr hohen Niveau gehalten; er fühlt sich nicht für kompetent um auch jene Übersichten zu kommentieren, die sich auf andere Länder beziehen.

Zahlreiche Schlussfolgerungen sind im letzten Kapitel zusammengefasst. Eine bemerkenswerte Konklusion ist die folgende: "Das allgemeine Angabenmaterial zeigt, dass in allen wichtigen Produktionsländern der Kartoffel die Fäulnisjahre einen grösseren Ertragspotential aufweisen wie trockene Jahre in denen die Fäule in geringerem Masse auftritt. Mit anderen Worten: die Dürre oder der Mangel an Regenfällen haben einen weit grösseren ertragsvermindernden Einfluss, wie die Fäule, und zwar bezieht sich dies nicht nur auf das nördliche Europa und Nordamerika, sondern auf die ganze Welt."

Eine ausführliche Bibliographie ist beigeschlossen. Wenn dieses Buch in erster Reihe für den Fachmann von Bedeutung ist, so hat es doch auch einen Wert für alle, die im Kartoffelanbau von anderen Ländern interessiert sind.

ÉPIDÉMIES DE MILDIOU DE LA POMME DE TERRE DANS LE MONDE

Cette étude importante a été rendue possible par la Wisconsin Alumni Research Foundation, aux Etats-Unis, qui fournit les fonds nécessaires à cette fin.

Les auteurs, faisant tous deux partie du personnel du Laboratoire de Pathologie Végétale du Ministère de l'Agriculture, des Pêcheries et de l'Alimentation à Harpenden en Angleterre, ont travaillé avec la collaboration d'environ 80 spécialistes de nombreux pays pour rassembler des données sur les épidémies de mildiou dans presque tous les pays du monde. Il est important et remarquable que leurs efforts aient eu pour résultat un ouvrage très lisible.

Cette étude avait les objectifs suivants:

1. étude le plus approfondie possible des données des pays où des recherches spéciales ont été exécutées;
2. diriger l'attention sur les méthodes utilisées;
3. appliquer en principe les résultats pour inter-

préter les données si dispersées provenant d'autres pays, afin de préparer la base d'un aperçu mondial pour le milieu du vingtième siècle.

Le domaine de la pomme de terre et celui du mildiou, ainsi que l'influence du climat sur l'un et l'autre, sont discutés dans l'introduction. Ensuite, il est donné des aperçus pour presque chaque pays où la pomme de terre et *Phytophthora infestans* ont quelque importance. Ils comprennent généralement des données sur:

1. la culture de la pomme de terre (répartition, superficie, production, variétés);
2. le climat;
3. prévisions concernant le mildiou de la pomme de terre;
4. répartition et fréquence des épidémies de mildiou;
5. pertes dues au mildiou;
6. moyens de lutte;

Les aperçus ne sont pas uniformes, attendu que l'on est mieux renseigné sur *Phytophthora infestans* dans certains pays que dans d'autres, et la longueur de l'aperçu ne constitue assurément pas une mesure de l'importance de la culture de pommes de terre ou bien du mildiou dans un pays donné. Le rapport relatif au propre pays du rédacteur (Pays-Bas) est de haute qualité; il ne se juge pas compétent à commenter ceux qui traitent d'autres pays.

Le dernier chapitre réunit de nombreuses conclusions. En voici une remarquable: "Les données générales permettent de constater que dans tous les principaux pays producteurs de pommes de terre du monde, le années de mildiou ont une plus grande récolte potentielle que les années sèches où le mildiou est moins important. Autrement dit, la sécheresse ou le déficit des précipitations ont une bien plus grande importance que le mildiou en ce qui concerne la réduction de la production de pommes de terre, ce qui est vrai non seulement dans le Nord de l'Europe et l'Amérique du Nord, mais dans tous les autres pays du monde".

L'ouvrage comprend une bibliographie importante. Bien qu'il soit tout d'abord important pour le spécialiste, cet ouvrage sera utile à toute personne qu'intéresse la culture de la pomme de terre dans d'autres pays.

EUROPEAN ASSOCIATION FOR POTATO RESEARCH

NOTICES OF THE COUNCIL OF THE ASSOCIATION – VORSTANDSMITTEILUNGEN – COMMUNICATIONS DU COMITÉ

The auditor's report on the financial position of the E.A.P.R. as at 31st December, 1959

To the Council of the European Association for Potato Research

Wageningen, 2nd August, 1960.
124 Lawickse Allee

The undersigned certifies that he has audited the Balance Sheet of your Foundation as at 31st December, 1959, and the Profit and Loss Account for 1959.

In his opinion these documents give a true picture of the financial position and of the results obtained.

C. A. Verheij,
Verheij Accountant's Office

BALANCE SHEET AS AT 31 DECEMBER 1959

Stock

Periodicals	f 1,—	
Printed Matter	- 1,—	
		f 2,—

Current Assets

Contributions	f 1939,—	
Subscriptions	- 2653,20	
Donors	- 3500,—	
Offprints supplied	- 1285,39	
Back numbers supplied	- 212,50	
Interest at Bank	- 244,21	
		- 9834,30

Prepaid expenses

- 12,—

Bank balances

Postal transfer account	f 2958,—	
Twentsche Bank	- 1778,23	
Nutsspaarbank	- 9117,58	
		- 13853,81

f 23702,11

Foundation Capital

Free reserve	f 972,24	
Free reserve, 1959 addition	- 1079,57	
		f 2051,81

Reserve for special purposes

Reserve	f 4000,—	
Reserve, 1959 addition	- 6000,—	
		- 10000,—

Guarantee Fund

- 6750,—

Items received in advance

Contributions	f 134,04	
Subscriptions	- 163,14	
		- 297,18

Short-term liabilities

Translation costs	f 35,—	
Editorial expenses	- 3,90	
Office expenses	- 1033,20	
Postage	- 21,75	
Bank + postal transfer charges	- 15,—	
Printing expenses	- 3494,27	
		- 4603,12

f 23702,11

C. A. VERHEIJ,
Verheij Accountant's Office

O. FISCHNICH, *President*
A. R. WILSON, *Vice-President*
20th August, 1960

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——— (1955): Osservazioni sulla comparsa della Maculatura ferruginea nei tuberi di patata. Centro Studi per la Patata, Bologna.

——— (1955): Osservazioni sulle deformazioni dei tuberi di patata. Centro Studi per la Patata, Bologna.

——— (1956): Osservazioni sulla Rizoctoniosi dei tuberi di patata. Centro Studi per la Patata, Bologna.

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[1] S.p.A. = Company Ltd.

(*Continuation of page IV*)

EUROPEAN POTATO JOURNAL
EUROPÄISCHE ZEITSCHRIFT FÜR KARTOFFELFORSCHUNG
REVUE EUROPEENNE DE LA POMME DE TERRE

Composition of the Journal: – Original contributions on fundamental and practical potato research, surveys of literature, letters to the Editor, news and reviews.
A volume of the Journal consists of four issues published in the same year and contains at least 240 pages. Papers are in English, German or French with summaries in at least these three languages.

Zusammenstellung der Zeitschrift: – Originalbeiträge über grundlegende und praktische Fragen der Kartoffel, Sammelreferate, Briefe an die Schriftleitung, Buchbesprechungen, Mitteilungen. Ein Jahrgang der Zeitschrift besteht aus vier Heften, jeder Band umfasst mindestens 240 Seiten. Die Beiträge sind in Englisch, Deutsch oder Französisch mit Zusammenfassungen in mindestens diesen drei Sprachen.

Composition du Journal: – Publications originales sur des recherches fondamentales ou pratiques concernant la pomme de terre, mises au point et analyses, communications à l'éditeur, avis.
Chaque volume du Journal comprend quatre numéros publiés au cours d'une année et contient au moins 240 pages. Les articles sont en anglais, allemand ou français avec des résumés en au moins ces trois langues.

Subscription to non-members: 25 Dutch guilders (or equivalent in other currencies).
Bezugspreis für Nichtmitglieder: 25 holl. Gulden (oder Gegenwert in anderer Währung).
Abonnement pour non-membres: 25 florins hollandais (ou l'équivalent en autres devises).

All correspondence should normally be addressed to the Editor, P.O. Box 20, Wageningen, Holland.

Alle Korrespondenz ist in der Regel zu richten an den Schriftleiter, P.O. Box 20, Wageningen, Holland.

Toute la correspondance doit être normalement adressée à l'éditeur, P.O. Box 20, Wageningen, Holland.

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1. Manuscripts should be sent to the nearest members of the Editorial Board or direct to the Editor in Wageningen. Although author's names are published without titles etc., manuscripts must bear the full name, titles etc., position and postal address of the contributor, together with the date of dispatch.
2. Manuscripts must be in English, French or German, type-written, double spaced with ample margins, on one side of good quality paper, and should be submitted in duplicate. A **short** summary must be provided in the language in which the paper is written. A **longer fully informative summary, in which reference should be made to the tables, figures etc. contained in the paper**, must also be provided, preferably in the remaining two languages mentioned above, otherwise in the language in which the paper is written. A summary in a language other than those mentioned above will be printed in addition if provided by the author.
3. A paper already published or under consideration for publication elsewhere, cannot be accepted but the Editor may, at his discretion, accept an abstract of such a paper.
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5. Diagrams should be drawn with black Indian ink on pale blue lined white graph paper or transparant paper, about twice the size of the finished block; shading must be indicated by lines or dots. *All lettering should be inserted in pencil outside the diagrams.* Photographs must be black and white with adequate contrast and printed on white glossy paper about twice the size of the finished block. Each diagram and each photograph must have a caption. Diagrams and photographs are taken together as figures and are numbered in one series as fig. 1, fig. 2, etc.
6. Sub-headings must be numbered and/or lettered and underlined with double or single lines in a consistent manner.
7. References must be listed alphabetically at the end of the article according to the "Harvard System" as follows: name and initial(s) of author (in capitals); year of publication in brackets, further distinguished by the addition of small letters a, b, c to the date where more than one paper published by the same author(s) in the same year is cited; exact title of paper; abbreviated title of periodical as given in *World List of Scientific Periodicals:* Volume number in arabic figures; first and last page number of article. In the text, references should be denoted by giving the name of the author(s) with the date of publication in brackets, e.g. (Smith, 1945), (Smith, 1945 a; Jones & Smith, 1942 a, b) In References where *more than two* collaborating authors are quoted in the text, the names are printed in full only at the first citation; after that the first name is followed by *et al.* References to publications other than periodicals, e.g. books, should include the name of the publisher and place of publication. Publications without a named author should be listed under "anonymous", abbreviated in the text to "anon".
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   Hinweise auf Bücher und andere nicht regelmässig erscheinende Veröffentlichungen: Name und Vorname(n) des Verfassers (siehe Angaben über Zeitschriften); Jahr der Veröffentlichung in Klammern; genauer Titel des Buches; Name und Ort des Verlegers.
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2. Les manuscrits doivent être rédigés en anglais, français ou allemand, dactylographiés avec double interligne et marges suffisamment larges sur une seule face d'un papier épais, et fournis en double exemplaire. Un **court** résumé doit être fourni dans la langue utilisée pour le manuscrit. En outre, il devra être fourni un **résumé plus détaillé se référant également aux tableaux, figures etc.,** de préférence dans les deux autres langues sus-mentionnées, autrement dans la langue du manuscript. Un résumé en une langue autre que les trois langues sus-mentionnées sera publié s'il est fourni par l'auteur.
3. Des articles qui auraient déjà été publiés ou qui seraient en cours de publication par ailleurs ne seront pas acceptés mais l'Editeur a le pouvoir d'en accepter des condensés.
4. Pour des raisons de place et de coût de production, les collaborateurs sont priés d'être aussi brefs que possible. Les résultats numériques doivent être présentés soit sous forme de tableaux, soit sous forme de diagrammes, mais pas sous les deux formes à la fois; seuls les tableaux, diagrammes et illustrations essentiels peuvent être publiés. Les articles doivent être conformes aux usages typographiques de la Revue. Les collaborateurs devront répondre de tous frais de correction excédant la normale.
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